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# MYCOTAXON

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OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

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# EIGHT NEW SPECIES IN THE LICHEN GENUS PARMELIA (ASCOMYCOTINA, PARMELIACEAE) FROM SOUTHERN AFRICA, WITH NOTES ON SOUTHERN AFRICAN LICHENS*

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## ABSTRACT

Eight new species in the lichen genus *Parmelia* (Parmeliaceae, Ascomycotina) are described from southern Africa. They are: *Parmelia antedeluvialis* Brusse & Sipman, *P. diutina* Brusse, *P. epacridea* Brusse, *P. erebea* Brusse, *P. manina* Brusse, *P. nautilomontana* Brusse, *P. pristiloba* Brusse and *P. tyrrhea* Brusse. Three new combinations are made: *Bullatina microcarpa* (Vezda) Brusse, *Cliostomum flavum* (Zahlbr.) Brusse and *Parmelia putsoa* (Hale) Brusse. Ten new records for southern Africa are reported. The name *Parmelia festiva* Brusse is explicitly typified, to exclude a discordant element.

## NEW SPECIES

**Parmelia antedeluvialis** Brusse & Sipman, *sp. nov.* Fig. 5.

Thallus ut in *Parmelia zambiense* Hale simili, sed sorediatus.

Thallus foliosus, saxicolus, usque ad 5 cm diam., sat adnatus. *Lobi* elongati, 0.5 - 3.0 mm lati, 50 - 230 μm crassi; axillis obtusis. *Thallus superne* flavoviridis, subnitidus vel hebetatus, leviter et reticulatim maculatus, soraliatus; soralia capitata, praecipue marginalia, usque ad 1 mm diam., sorediis grossis, 35 - 80 μm diam.; epicortex porosus, sed cum crystallis inclusus. *Cortex superior* 10 - 20 μm crassus. *Stratum gonidiale* 10 - 50 μm crassum, algis *Trebouxiis*. *Medulla* alba, 15 - 160 μm crassa. *Cortex inferior* 9 - 14 μm crassus. *Thallus inferne* piceus, sat rhizinatus. *Rhizinae* simplices, ad 1 mm longae, prope basin 40 - 120 μm crassae. *Apothecia* non visa. *Pycnidia* non visa. *Thallus* acidum usnicum, acidum divaricaticum et acidum nordivaricaticum continens.

**TYPUS:** SOUTH AFRICA, TRANSVAAL - **2430** (Pilgrim's Rest): **-DB** (Vaalhoek) Treur River near Bourke's Luck. Sandstone rock outcrops in steep grassland slope. On rock, in fissure. Alt. 1400 m. *H. Sipman 19906*, 14. i. 1986 (**B**, holo-). Figura 5.

Thallus as in *Parmelia zambiensis* Hale except sorediate.

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* This paper is dedicated in memory of the late Dr. T. Douglas V. Swinscow in recognition of his major contribution to the knowledge of East African macrolichens.

Thallus foliose, saxicolous, up to 5 cm across, moderately adnate. *Lobes* elongate, 0.5 - 3.0 mm wide, 50 - 230 μm thick, axils obtuse. *Upper surface* yellow-green, subglossy to matt, faintly reticulately maculate, soraliate; soralia capitate, mainly marginal, up to 1 mm across, soredia coarse, 35 - 80 μm diam.; epicortex pored, but with embedded crystals. *Upper cortex* 10 - 20 μm thick. *Algal layer* 10 - 50 μm thick, algae *Trebouxia*. *Medulla* white, 15 - 160 μm thick. *Lower cortex* dark brown, 9 - 14 μm thick. *Lower surface* black, moderately rhizinate. *Rhizines* simple, to 1 mm long, 40 - 120 μm thick near base. *Apothecia* not seen. *Pycnidia* not seen. *Chemistry*: usnic, divaricatic and nordivaricatic acids.

**Etymology**: *ante* (L) = before; *eluvio* (L) = flood, inundation.

*Parmelia antedeluvialis* is named in apprehension of the Blyde Poort Dam, which occurs some distance downstream from the type locality. As this species, without doubt, antedates this dam (albeit unnamed until now), it is here given this name. However, as this species is probably fairly widespread, the construction of this dam, posed no threat to it.

This new species resembles the non-sorediate *Parmelia zambiensis* Hale, and can be considered the sorediate counterpart of the latter. The lobes of *P. antedeluvialis* are slightly narrower than those of *P. zambiensis*, but this is a relatively minor difference.

So far, this new species is only known from the type collection from near Bourke's Luck potholes, on sandstone of the Transvaal Sequence in rock fissures (i.e. shaded).

**Parmelia diutina** Brusse, *sp. nov.* Fig. 6.

Thallus parvofoliosus, saxicolus, usque ad 5 cm diam., arcte adnatus vel subcrustosus. *Lobi* elongati vel sublineares, 0.1 - 0.8 mm lati, 100 - 250 μm crassi. *Thallus superne* viridis vel olivaceus, nitidus vel subnitidus, isidiis sorediisque destitutus; epicortice poroso. *Cortex superior* 15 - 20 μm crassus. *Stratum gonidiale* 20 - 50 μm crassum, algis *Trebouxiis*. *Medulla* alba, 60 - 180 μm crassa. *Cortex inferior*, 11 - 13 μm crassus. *Thallus inferne* pallide brunneus. *Rhizinae* parvae, ad 0.15 mm longae, prope basin 30 - 65 μm crassae, simplices. *Apothecia* (rite evoluta) non visa. *Pycnidia* non visa. *Thallus* acidum usnicum, acidum sticticum, acidum consticticum, acidum menegazziaicum (min.), et duo pigmenta flava ignota continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-DC** (Langvlei) Summit of Jona's Head in the Riviersonderend Mountains near Villiersdorp. On NW side of boulder on ledge of steep S Table Mountain Sandstone cliffs. Alt. 1630 m. *F. Brusse 6296*, 14. xii. 1991 (**PRE**, holo-; **BM**, iso-). Figura 6.

Thallus small foliose, saxicolous, up to 5 cm across, tightly adnate or subcrustose. *Lobes* elongate to sublinear, 0.1 - 0.8 mm wide, 100 - 250 μm thick. *Upper surface* green to olive-green, glossy to subglossy, neither isidia nor soredia present; pored epicorticate. *Upper cortex* 15 - 20 μm thick. *Algal layer* 20 - 50 μm thick, algae *Trebouxia*. *Medulla* white, 60 - 180 μm thick. *Lower cortex* 11 - 13 μm thick. *Lower surface* pale brown. *Rhizines* small, to 0.15 mm long, 30 - 65 μm thick near base, simple. *Apothecia*: only immature ones seen. *Pycnidia* not seen. *Chemistry*: usnic, stictic, constictic, menegazziaic(min.) acids and two unknown yellow pigments present.

This is another new subcrustose species, and differs from all others in its chemistry. Only immature apothecia are present on the type material, and these are adnate. *P. diutina* differs from *P. adhaerens* Nyl. and *P. adligans* Brusse by having adnate, rather than sunken, apothecia, a glossy, rather than matt upper surface, and a pored, rather than absent epicortex, besides the differing chemistries. Both *P. adhaerens* and *P. adligans* lack an epicortex. *P. adligans* consistently contains atranorin, in addition to usnic acid, as well as cryptostictic acid in addition to the stictic, constictic and menegazziaic (±) acids present in both, and also lacks the yellow pigments of *P. diutina*. Brusse (1988) originally thought this accessory substance (menegazziaic acid) may be methylstictic acid, but Dr. J. A. Elix (Canberra, *in litt.*) has since indicated that this is in fact menegazziaic acid. *P. adhaerens* is similar to *P. diutina* in chemistry, but contains hypostictic and hypoconstictic acids in addition to the stictic and usnic acids present in both, and lacks the yellow pigments.

Thus far, this new species has only been collected at the type locality, Jona's Head, in Riviersonderend Mountains near Villiersdorp.

**Parmelia epacridea** Brusse, *sp. nov.* Fig. 7.

Thallus parvofoliosus, saxicolus, usque ad 3 cm diam., sat vel laxe adnatus. *Lobi* sublineares vel lineares, 0.1 - 0.8 mm lati, 60 - 180 μm crassi. *Thallus superne* viridis vel glauco-viridis, nitidus vel subnitidus, isidiis sorediisque destitutus; epicortice poroso. *Cortex superior* 8 - 20 μm crassus. *Stratum gonidiale* 15 - 60 μm crassum, algis *Trebouxiis*. *Medulla* alba, 10 - 120 μm crassa. *Cortex inferior* atrobrunneus, 9 - 15 μm crassus. *Thallus inferne* piceus, parce rhizinoideus. *Rhizinoidae* ad 1 mm longae, prope basin 40 - 90 μm crassae, simplices sed saepe duplices vel complanatae. *Apothecia* non visa. *Pycnidia* sparsa, hyalina, globosa, circa 100 μm diam. *Spermatia* acicularia, hyalina, recta, 5.5 - 9.0 X 0.8 μm. *Thallus* acidum isousnicum, acidum sticticum et acidum consticticum continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3219** (Wuppertal): **-AC** (Wuppertal) Cedarberg Table Mountain near Clanwilliam. SW cliffs opposite "the spout". In SW facing Table Mountain Sandstone rock hollow, at base of summit cliffs. Alt. 1880 m. *F. Brusse 6065*, 19. xi. 1991 (**PRE**, holo-; **BM**, **LD**, iso-). Figura 7.

Thallus small foliose, saxicolous, up to 3 cm across, moderately to loosely adnate. *Lobes* sublinear to linear, 0.1 - 0.8 mm wide, 60 - 180 μm thick. *Upper surface* green to glaucous-green, glossy to subglossy, isidia and soredia lacking; pored epicorticate. *Upper cortex* 8 - 20 μm thick. *Algal layer* 15 - 60 μm thick, algae *Trebouxia*. *Medulla* white, 10 - 120 μm thick. *Lower cortex* dark brown, 9 - 15 μm thick. *Lower surface* black, with sparse rhizinoids. *Rhizinoids* to 1 mm long, 40 - 90 μm thick near base, simple but often duplex or flattened, the tip sometimes shortly bifurcate, and also sometimes white. *Apothecia* not seen. *Pycnidia* sparse, hyaline, globose, *ca.* 100 μm diam. *Spermatia* hyaline, straight, needles, 5.5 - 9.0 X 0.8 μm. *Chemistry*: isousnic, stictic and constictic acids.

This new species is very similar to *Parmelia xanthomelaena* Müll. Arg., which is a very common species in this area in more usual positions. *Parmelia epacridea* differs in containing isousnic acid instead of usnic acid, and in being restricted to shallow rock overhangs, which must receive less precipitation than more exposed positions. *Parmelia putida* Brusse is another similar species with the identical chemistry, but this lichen is completely brown with the N+ green glomellifera-brown pigment in the upper cortex, and does not occur in shallow rock overhangs, but on steep south facing cliffs instead.

The rhizines of *P. epacridea* are unusual in the artificial section *Xanthoparmelia* in that they are duplex, that is, consist of two rhizines fused together along their length. The tips of the rhizinoids are frequently white, and shortly bifurcate, indicating the origin of these structures. Some rhizinoids even possess a longitudinal groove down the centre of both flattened faces, clearly showing that the rhizinoids are, in fact, two rhizines fused together. *P. xanthomelaena* and *P. putida*, in contrast, have normal rhizines.

Thus far, this new species has only been collected at the type locality, the Cedarberg Table Mountain near Clanwilliam.

**Parmelia erebea** Brusse, *sp. nov.* Fig. 8.

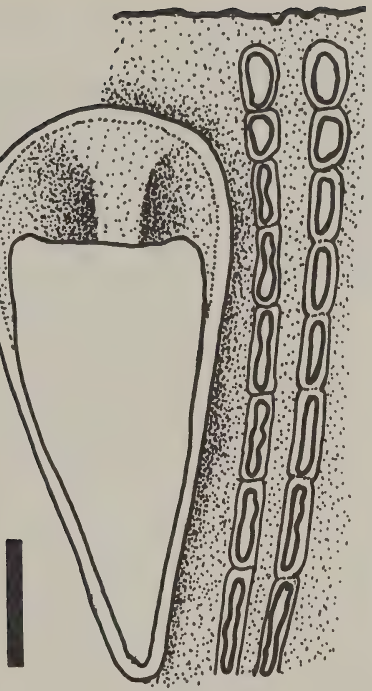
Thallus foliosus, saxicolus, usque ad 4 cm diam., sat adnatus. *Lobi* elongati, 0.5 - 2.0 mm lati, 95 - 230 μm crassi. *Thallus superne* cinereus vel fumosus, subnitidus, isidiis sorediisque destitutus; epicortice poroso. *Cortex superior* 10 - 20 μm crassus. *Stratum gonidiale* 20 - 35 μm crassum, algis *Trebouxiis*. *Medulla* albida, 20 - 170 μm crassa. *Cortex inferior* 12 - 18 μm crassus. *Thallus inferne* pallide brunneus, sat rhizinatus. *Rhizinae* simplices, ad 0.6 mm longae, prope basin 40 - 150 μm crassae. *Apothecia* adnata, usque ad 2 mm diam. *Hypothecium* hyalinum, 30 - 40 μm crassum, J-. *Subhymenium* hyalinum, 5 - 10 μm crassum, J+ pallide caeruleum. *Epihymenium* pallide badium, N-. *Hymenium* hyalinum, 45 - 55 μm altum, J+ caeruleum. *Asci* clavati, cum tholis J+ caeruleis (fig. 1), dehiscentiis rostratis. *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 9 - 11 X 6 - 7 μm. *Pycnidia* hyalina, globosa, circa 120 μm diam. *Spermatia* acicularia, hyalina, recta, 5 - 6.5 X 0.7 μm. *Thallus* atranorinum, chloroatranorinum (min.), acidum stenosporonicum, acidum colensoicum (min./vest.) et acidum divaronicum (min./vest.) continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3119** (Calvinia): **-AC** (Nieuwoudtville) Van Rhynspas, aan klip. *P. A. van der Bijl 760(b)*, ix. 1928 (**PREM**, holo-; **W**, iso-). Figura 8.

Thallus foliose, saxicolous, up to 4 cm across, moderately adnate. *Lobes* elongate, 0.5 - 2.0 mm wide, 95 - 230 μm thick. *Upper surface* grey to smoky-grey, subglossy, neither isidiate nor sorediate; pored epicorticate. *Upper cortex* 10 - 20 μm thick. *Algal layer* 20 - 35 μm thick, algae *Trebouxia*. *Medulla* whitish, 20 - 170 μm thick. *Lower cortex* 12 - 18 μm thick. *Lower surface* pale brown, darkening towards the lobe tips, moderately rhizinate. *Rhizines* simple, to 0.6 mm long, 40 - 150 μm thick near base. *Apothecia* adnate, up to 2 mm across. *Hypothecium* hyaline, 30 - 40 μm thick, J-. *Subhymenium* hyaline, 5 - 10 μm thick, J+ pale blue. *Epihymenium* toffee brown, N-. *Hymenium* hyaline, 45 - 55 μm high, J+ blue. *Asci* clavate, eight-spored; tholus J+ blue (fig. 1), dehiscence rostrate. *Ascospores* hyaline, monolocular, ellipsoid, 9 - 11 X 6 - 7 μm. *Pycnidia* hyaline, globose, *ca.* 120 μm diam. *Spermatia* hyaline, straight, needles, 5.0 - 6.5 X 0.7 μm. *Chemistry*: atranorin, chloroatranorin (min.), stenosporonic, colensoic (min./tr.), and divaronic (min./tr.) acids.

This is a fairly ordinary looking species, except the chemistry is unusual for this group of grey, saxicolous Parmeliae. The only other grey species known to contain stenosporonic acid in the medulla, is the much smaller *Parmelia mongaensis* Elix, which also occurs in southern Africa. Unlike this new species, *P. mongaensis* is black below as well.

The type material of *Parmelia vanderbylii* Zahlbr. is mixed with the type material of this new species. The material at **PREM**, is the least contaminated with *P. vanderbylii*, and is therefore chosen as the holotype of *P. erebea* Brusse. The holotype of *P. vanderbylii* at **W**, also has two small pieces of this new species with it, labelled "b1" & "b2" by me on the type sheet, the true *P. vanderbylii* being marked "a". There is also a small isotype of *P. vanderbylii* at **LD**, but this specimen is not growing with *P. erebea*, and is purely *P. vanderbylii*. The *Almborn 5110* specimen mentioned by Hale (1976), is also probably this new species, but this specimen could not be traced at **LD** (Per Lassen, *in litt.*).



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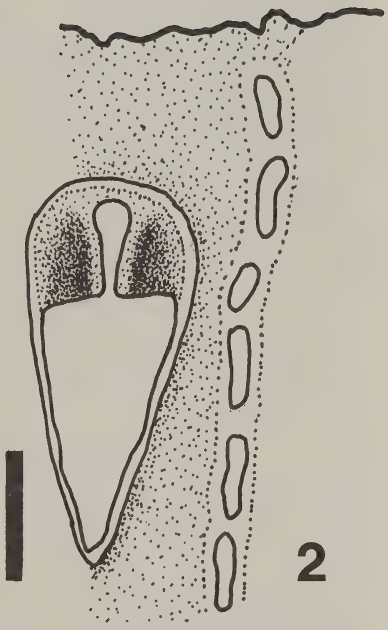

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FIGURE 1. - *Parmelia erebea* Brusse, ascus and paraphyses. *P. A. van der Bijl 760(b)*, holotype. Bar = 10 μm.

FIGURE 2. - *Parmelia manina* Brusse, ascus and paraphysis. *F. Brusse 6085*, holotype. Bar = 10 μm.

The **P. A. van der Bijl collection of lichens and fungi** has previously been unavailable for loan because of its status as a private collection in the Botany Department of Stellenbosch University, but has recently been transferred to **PREM** (herbarium abbreviations as in Holmgren *et al*. 1990), and loans from this collection are now freely available (A. Baxter, personal communication). This valuable collection is rich in isotypes of lichen species described on his numbers by Vainio and Zahlbruckner.

Great care has to be taken to differentiate *P. erebea* from *P. vanderbylii* as these two lichens both react only KC+ pink, and are very similar looking. However, *P. vanderbylii* Zahlbr. contains two unknown substances in the medulla, whereas *P. erebea* Brusse contains stenosporonic acid in the medulla, with only minor to trace amounts of colensoic and divaronic acids present. The type material of *P. vanderbylii* Zahlbr. is definitely excluded from the present protologue of *P. erebea* Brusse, by the designation of a new P. A. van der Bijl collection number, *viz*. 760b, based on part of his previous number, 760.

This new species is known from the west coast escarpment, from near Vanrhynsdorp to possibly as far south as Bain's Kloof, near Wellington (*Almborn 5110*).

**Parmelia manina** Brusse, *sp. nov.* Fig. 9.

Thallus effigurato-crustosus, saxicolus, usque ad 4 cm diam. *Lobi* elongati, 1 - 3 mm longi, 0.2 - 1.0 mm lati, 80 - 240 μm crassi. *Thallus superne* brunneus, nitidus, isidiis sorediisque destitutus; epicortice poroso. *Cortex superior* 10 - 15 μm crassus. *Stratum gonidiale* 20 - 50 μm crassum, algis *Trebouxiis*. *Medulla* alba, 40 - 160 μm crassa. *Cortex inferior* 7 - 12 μm crassus. *Thallus inferne* pallide brunneus, rhizinis non bene evolutis. *Apothecia* adnata, usque ad 1.7 mm diam. *Hypothecium* hyalinum, 35 - 50 μm crassum, J-. *Subhymenium* hyalinum, 10 - 20 μm crassum, J+ pallide caeruleum. *Epihymenium* pallide badium, N+ fugacium cyaneum vel cyanatrum, dein schistaceum, denique decolorans. *Hymenium* hyalinum, 45 - 60 μm altum, J+ caeruleum. *Asci* clavati, cum tholis J+ caeruleis (fig. 2). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 8.5 - 10.5 X 6 - 7 μm. *Pycnidia* hyalina, globosa, circa 120 μm diam. *Spermatia* acicularia, hyalina, recta, 6 - 10 X 0.8 μm. *Thallus* acidum succinoprotocetraricum, et materiam ignotam continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-AD** (Ceres) NW end of Waaihoek Mountains. Summit of the lower Mosterthoek Twin, between Ceres and Wolseley. On loose Table Mountain Sandstone rock, between two boulders near summit. Alt. 1940 m. *F. Brusse 6085*, 24. xi. 1991 (**PRE**, holo-; **BM**, iso-). Figura 9.

Thallus effigurate-crustose, saxicolous, up to 4 cm across. *Lobes* elongate, 1 - 3 mm long, 0.2 - 1.0 mm wide, 80 - 240 μm thick. *Upper surface* brown, glossy, isidia and soredia lacking; pored epicorticate. *Upper cortex* 10 - 15 μm thick. *Algal layer* 20 - 50 μm thick, algae *Trebouxia*. *Medulla* white, 40 - 160 μm thick. *Lower cortex*, 7 - 12 μm thick. *Lower surface* pale brown, rhizines not well developed. *Apothecia* (common on paratype, but rare on holotype) adnate, up to 1.7 mm across. *Hypothecium* hyaline, 35 - 50 μm thick, J-. *Subhymenium* hyaline, 10 - 20 μm thick, J+ pale blue. *Epihymenium* toffee brown, N+ fleeting blue, then blue-grey, finally fading. *Hymenium* hyaline, 45 - 60 μm high, J+ blue. *Asci* clavate, eight-spored; tholus J+ blue (fig. 2). *Ascospores* hyaline, monolocular, ellipsoid, 8.5 - 10.5 X 6 - 7 μm. *Pycnidia* sparse, hyaline, globose, *ca.* 120 μm diam. *Spermatia* hyaline, straight, needles, 6 - 10 X 0.8 μm. *Chemistry*: succinoprotocetraric acid and an unknown K+ red substance present.

*Parmelia manina* is another brown, effigurate-crustose lichen resembling *Parmelia squamariata* Nyl. The spot tests on these two lichens are identical, with both becoming yellow on application of K (a 2 molar aqueous solution of potassium hydroxide), which subsequently slowly changes to dark red. However, in *P. squamariata* this is due to the presence of norstictic acid, whereas in *P. manina* this is due to an unknown substance, and succinoprotocetraric acid is also present.

The epihymenium of this new lichen is interesting, in that the normal toffee-brown colour is accompanied by a second yellowish insoluble pigment, which often protrudes below the toffee-brown zone as a yellowish haze or lining. This yellowish wash in the epihymenium reacts with concentrated nitric acid (abbreviated N in this context), to give a fleeting prussian blue colour (which is often masked by the toffee-brown colour also present, to give an apparent dark blue colour). This fleeting blue colour then changes to a greyish colour, which fades to almost colourless within 5 minutes. Sometimes when the yellowish pigment is present in low concentrations, the brown epihymenium colour merely becomes dark blue momentarily, then reverts back to the previous brown colour. These colour reactions have to be performed on hymenial sections, under a coverslip, on a glass slide in position on the stage of a compound light microscope. A piece of blotting- or filter paper is cut into a rectangle of suitable size, and placed against the coverslip so that the water that the hymenial sections are in, is drawn away by capillary action. When most of the excess water has been removed, a drop of concentrated nitric acid is placed at the opposite edge of the coverslip, by means of a drawn-out pasteur pipette equipped with a rubber teat. The concentrated nitric acid will then be drawn in under the coverslip, and come into contact with the sections. (*Caution: concentrated nitric acid is a dangerous liquid, and should be handled carefully. The nitric acid should not be allowed to splash onto the objective lens assembly, or for that matter on any part of the microscope, as nitric acid reacts with most metals, producing water soluble nitrates of these metals. If inadvertent splashing has occurred, it should be washed off with water immediately. A solution of sodium bicarbonate at hand is also useful in the case of inaccessible splashes and splashes on clothing which cannot be rapidly removed for washing*).

This epihymenial reaction occurs in several effigurate-crustose Parmeliae. An N+ fleeting blue reaction occurs in the epihymenium of *P. leptoplaca* (Zahlbr.) Brusse, *P. pristiloba* Brusse (described below), *Karoowia protocetrarica* Hale, *P. squamatica* Brusse, and in all effigurate-crustose brown specimens seen by me, although I have not examined the type of *P. squamariata* Nyl. The application of the name *Karoowia* Hale in this context is not certain, because the type material of its type species, *Parmelia adhaerens* Nyl., is sterile. Nevertheless, many of the species placed in this genus are negative to this test, including *P. adligans* Brusse, *P. arquata* Brusse, *P. insipida* Brusse and *P. ralla* Brusse. Some species, such as *P. lyrigera* Brusse, are sterile, and this character state cannot be determined for them. The remaining species placed in *Karoowia* by Hale (1989) are aberrant, in having adnate (not immersed) apothecia, and in possessing an epicortex (not non-epicorticate). These remaining species also give a negative reaction with concentrated nitric acid in the epihymenium.

*Parmelia manina* is so far known from two localities, the type locality - the Mosterthoek Twins near Ceres and Wolseley, and from Keerom Mountain near Worcester.

Additional Specimen Examined:

SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-DA** (Nuy) Summit of Keerom Mountain near Worcester. On a sloped face of a Table Mountain Sandstone rock, on S to SW slope. Alt. 2070 m. *F. Brusse 6191*, 01. xii. 1991 (**BM, PRE**).

**Parmelia nautilomontana** Brusse, *sp. nov.* Fig. 10.

Thallus umbilicato-foliosus, saxicolus, usque ad 3 cm diam. *Lobi* ascendentes, sublineares, coriacei, 0.2 - 3.0 mm lati, 80 - 350 μm crassi, irregulariter dissecti. *Thallus superne* brunneus vel atrobrunneus, N-, subnitidus vel scabridus, leviter maculatus, isidiis sorediisque destitutus; epicortex porosus, poris aggregatis. *Cortex superior* 15 - 30 μm crassus. *Stratum gonidiale* 20 - 70 μm crassum, algis *Trebouxiis*. *Medulla* alba, 30 - 230 μm crassa, hic illic chondroidea. *Cortex inferior* 13 - 30 μm crassus. *Thallus inferne* pallide brunneus, ad apicem versus fuscans, non-rhizinatus. *Apothecia* adnata vel substipitata, numerosa, usque ad 6 mm diam. *Hypothecium* hyalinum, 45 - 65 μm crassum, J-. *Subhymenium* hyalinum, 10 - 15 μm crassum, J+ pallide caeruleum. *Epihymenium* pallide badium, N-. *Hymenium* hyalinum, 40 - 50 μm altum, J+ caeruleum. *Asci* clavati, cum tholis J+ caeruleis (fig. 3), dehiscentiis rostratis. *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 7 - 10 X 4 - 5.5 μm. *Pycnidia* hyalina, globosa, circa 120 μm diam. *Spermatia* acicularia, hyalina, recta, 6 - 8.5 X 0.8 μm. *Thallus* acidum gyrophoricum solum continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-BC** (De Doorns) Hex River Mountains. Summit of Matroos Mountain, near De Doorns. On E Table Mountain Sandstone rock face, on NW slope, near end of large gorge, below peak hut. Alt. 2220 m. *F. Brusse 6152*, 28. xi. 1991 (**PRE**, holo-; **BM**, iso-). Figura 10.

Thallus umbilicate-foliose, saxicolous, up to 3 cm across. *Lobes* ascending, sublinear, leathery and tough-textured, 0.2 - 3.0 mm wide, 80 - 350 μm thick, variably dissected. *Upper surface* brown to dark brown, N-, subglossy to scabrous, lightly maculate, not isidiate and not sorediate; epicortex cluster-pored. *Upper cortex* 15 - 30 μm thick. *Algal layer* 20 - 70 μm thick, algae *Trebouxia*. *Medulla* white, 30 - 230 μm thick, chondriod in places. *Lower cortex* 13 - 30 μm thick. *Lower surface* pale brown, darkening towards the lobe tips, rhizines absent, smooth to wrinkled, often transversely wrinkled (barred) towards the umbilicus, matt. *Apothecia* adnate to substipitate, abundant, up to 6 mm across. *Hypothecium* hyaline, 45 - 65 μm thick, J-. *Subhymenium* hyaline, 10 - 15 μm thick, J+ pale blue. *Epihymenium* toffee brown, N-. *Hymenium* hyaline, 40 - 50 μm high, J+ blue. *Asci* clavate, eight-spored; tholus J+ blue (fig. 3), dehiscence rostrate. *Ascospores* hyaline, monolocular, ellipsoid, 7 - 10 X 4 - 5.5 μm. *Pycnidia* hyaline, globose, *ca.* 120 μm diam. *Spermatia* hyaline, straight, needles, 6 - 8.5 X 0.8 μm. *Chemistry*: gyrophoric acid only.

**Etymology:** *nauta* (L) = sailor (*matroos* (Dutch) = sailor); *montana* (L) = from / relating to a mountain.

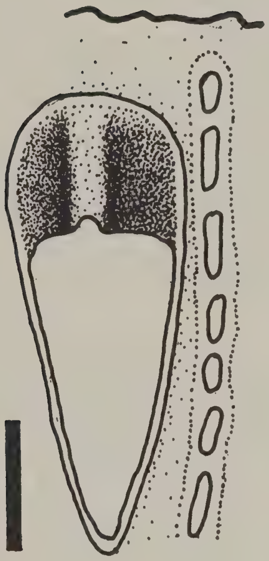
The habit of this new lichen is similar to *Gyrophora polyphylla* (L.) Funck, but the thallus is more clearly umbilicate than the latter, and the apothecia are clearly Parmeliaceous, not absent, as is usually the case in the latter. When present, the apothecia are gyrose in *G. polyphylla*, and the ascus apex is of the Gyrophora-type (this tholus type resembles the Lecidea-type apex), rather than of the Lecanora-type apex present in this new species. Sometimes some other brown Parmeliae, such as *P. foveolata* Essl., approach the umbilicate habit of this new species. Some non-brown species also show this characteristic, including *P. hyporhytida* Hale and, of course, the well known *P. hottentotta* (Thunb. ex Ach.) Ach. A peltate lichen has recently been described from Argentina as *Omphalodiella patagonica* Henssen (1991). This lichen contains the same secondary metabolite as *P. nautilomontana*, but *O. patagonica* has immersed cryptolecanorine apothecia, rather than Parmelioid apothecia. There are several other morphological features that distinguish these two lichens, one of the most conspicuous being the small oval to spherical ascospores, 4 - 6 X 4 - 5 μm, of *O. patagonica*.

The partially chondroid tissue in the medulla of this new species is also found in several other brown Parmeliae, including *P. foveolata* Essl., *P. dregeana* Nyl. and *P. adamantea* Brusse, while the medulla is almost completely chondroid in *Almbornia cafferensis* Essl. and *A. azaniensis* Brusse. All these lichens are rather tough and leathery because of this, and the lobes are difficult to break by pulling apart with forceps. Although there are no close relatives of *P. nautilomontana*, *P. foveolata* is, in my opinion, the most nearly related, but the upper cortex of the former lacks "glomellifera brown".

Thus far, this new species is known only from the type locality, Matroos Mountain near De Doorns.

### **Parmelia pristiloba** Brusse, *sp. nov.* Fig. 11.

Thallus effigurato-crustosus, saxicolus, usque ad 3 cm diam. *Lobi* elongati, 1 - 4 mm longi, 0.2 - 1.2 mm lati, 70 - 200 μm crassi. *Thallus superne* cinereus, subnitidus, isidiis sorediisque destitutus; epicortex destitutus. *Cortex superior* 15 - 20 μm crassus. *Stratum gonidiale* 25 - 50 μm crassum, algis *Trebouxiis*. *Medulla* alba, 10 - 120 μm crassa, J-. *Cortex inferior* ad apicem versus solum evolutus, ca. 5 μm crassus. *Thallus inferne* pallide brunneus, sat rhizinatus. *Rhizinae* non bene evolutae. *Apothecia* immersa, numerosa, usque ad 0.5 mm diam., discis atris. *Hypothecium* hyalinum, 55 - 70 μm crassum, J-. *Subhymenium* hyalinum, 10 - 20 μm crassum, J+ pallide caeruleum. *Epihymenium* badium, N+ fugacium cyaneum vel atrocyaneum. *Hymenium* hyalinum, 45 - 55 μm altum, J+ caeruleum. *Asci*



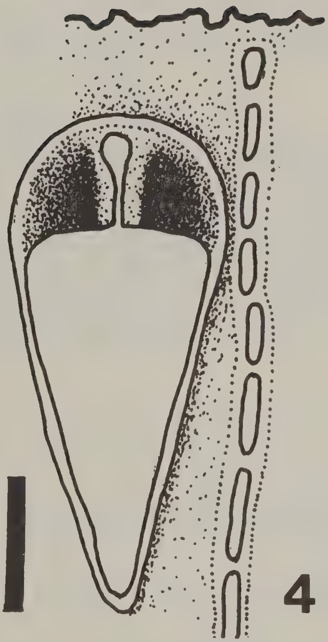


FIGURE 3. - *Parmelia nautilomontana* Brusse, ascus and paraphysis. *F. Brusse 6152*, holotype. Bar = 10 μm.

FIGURE 4. - *Parmelia pristiloba* Brusse, ascus and paraphysis. *F. Brusse 6017*, holotype. Bar = 10 μm.

clavati, cum tholis J+ caeruleis (fig. 4). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 7 - 9 X 5.5 - 6.5 μm. *Pycnidia* hyalina, globosa, circa 100 μm diam. *Spermatia* acicularia, hyalina, recta, 7 - 11 X 0.8 μm. *Thallus* acidum baeomycesicum, acidum squamaticum (min.) et acidum lichesterinicum continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3219** (Wuppertal): **-CD** (De Meul) Cold Bokkeveld Table Mountain near Op-die-Berg. Farm: Tafel Berg. Half way up E side of mountain. On top of Table Mountain Sandstone boulder, on fairly steep E slope. Alt. 1500 m. *F. Brusse 6017*, 17. xi. 1991 (**PRE**, holo-; **BM**, **LD**, iso-). Figura 11.

Thallus effigurate-crustose, saxicolous, up to 3 cm across. *Lobes* elongate, 1 - 4 mm long, 0.2 - 1.2 mm wide, 70 - 200 μm thick. *Upper surface* grey, subglossy, isidia and soredia lacking; epicortex absent. *Upper cortex* 15 - 20 μm thick. *Algal layer* 25 - 50 μm thick, algae *Trebouxia*. *Medulla* white, 10 - 120 μm thick, J-. *Lower cortex* only developed at lobe tips, *ca.* 5 μm thick. *Lower surface* pale brown, moderately rhizinate. *Rhizines* not well developed. *Apothecia* immersed (cryptolecanorine), common, up to 0.5 mm across, disc black. *Hypothecium* hyaline, 55 - 70 μm thick, J-. *Subhymenium* hyaline, 10 - 20 μm thick, J+ pale blue. *Epihymenium* chestnut brown, N+ fleeting dark blue. *Hymenium* hyaline, 45 - 55 μm high, J+ blue. *Asci* clavate, eight-spored; tholus J+ blue (fig. 4). *Ascospores* hyaline, monolocular, ellipsoid, 7 - 9 X 5.5 - 6.5 μm. *Pycnidia* hyaline, globose, *ca.* 100 μm diam. *Spermatia* hyaline, straight, needles, 7 - 11 X 0.8 μm. *Chemistry*: baeomycesic, squamatic (min.) and lichesterinic acids (no atranorin).

This is another very distinctive effigurate-crustose species. As mentioned under *P. manina* Brusse (above), this lichen has a chestnut brown epihymenium with a yellowish wash, which turns a fleeting dark blue on treatment with concentrated nitric acid, rapidly fading to blue-grey, and subsequently slowly bleaching to almost colourless. This character is discussed in detail under *P. manina*.

There are no close relatives of this distinct new lichen, but it resembles *Protoparmelia plicatula* (Müll. Arg.) Rambold in chemistry in that it also contains baeomycesic and squamatic acids. However, the latter is a lichen with a lecideine exciple, not a cryptolecanorine one like *P. pristiloba*, and has narrower ascospores, much longer, curved and flexible spermatia, and a crustose (not effigurate-crustose) thallus, with a well developed epinecral layer (Rambold 1989).

**Parmelia tyrrhea** Brusse, *sp. nov.* Fig. 12.

Thallus parvofoliosus, saxicolus, usque ad 3 cm diam., sat vel sublaxe adnatus. *Lobi* sublineares, 0.2 - 0.8 mm lati, 70 - 260 μm crassi. *Thallus superne* flavo-viridis, subnitidus, leviter reticulatim maculatus, aggregato-isidiatus; isidia parva, aggregata vel interdum discreta, cylindrica vel globosa, laminalia, fragilia, usque ad 0.15 mm crassa et 0.3 mm longa; epicortice poroso. *Cortex superior* 10 - 20 μm crassus. *Stratum gonidiale* 15 - 50 μm crassum, algis *Trebouxiis*. *Medulla* albida, 20 - 200 μm crassa. *Cortex inferior* 9 - 12 μm crassus. *Thallus inferne* pallide brunneus, ad apicem versus fuscans, sat rhizinatus. *Rhizinae* simplices, parvae, ad 0.35 mm longae, prope basin 30 - 70 μm crassae. *Apothecia* non visa. *Pycnidia* non visa. *Thallus* acidum usnicum, acidum hyposticticum, acidum hyposalazinicum, acidum sticticum, acidum hypoconsticticum et acidum consticticum continens.

**TYPUS:** SOUTH AFRICA, CAPE PROVINCE - **3219** (Wuppertal): **-AC** (Wuppertal) Cedarberg Table Mountain near Clanwilliam. SW cliffs opposite "the spout". In SW facing Table Mountain Sandstone rock hollow, at base of summit cliffs. Alt. 1880 m. *F. Brusse 6064*, 19. xi. 1991 (**PRE**, holo-; **BM**, **LD**, iso-). Figura 12.

Thallus small foliose, saxicolous, up to 3 cm across, moderately to somewhat loosely adnate. *Lobes* sublinear, 0.2 - 0.8 mm wide, 70 - 260 μm thick, usually mildly convex. *Upper surface* yellow-green, subglossy, lightly reticulately maculate, clustered isidiate; isidia small, clustered to sometimes discrete, laminal, cylindrical to globose, fragile, up to 0.15 mm thick and 0.3 mm tall, often more pale and yellower than the upper surface, and can cover the whole lobe surface sometimes; epicortex pored. *Upper cortex* 10 - 20 μm thick. *Algal layer* 15 - 50 μm thick, algae *Trebouxia*. *Medulla* whitish, 20 - 200 μm thick. *Lower cortex* 9 - 12 μm thick. *Lower surface* pale brown, darkening towards the lobe tips, moderately rhizinate. *Rhizines* simple, small, up to 0.35 mm long, 30 - 70 μm thick near base, darker than the lower surface in pale areas. *Apothecia* not seen. *Pycnidia* not seen. *Chemistry*: usnic, hypostictic, hyposalazinic, stictic, hypoconstictic and constictic acids present.

*Parmelia tyrrhea* was found in the same small rock overhang as *P. epacridea* described above. *P. tyrrhea* superficially resembles another overhang Xanthoparmelia, *P. geckonalis* Brusse. However, the latter lichen is truely pustular, and produces coarse soredia when optimally developed, whereas *P. tyrrhea* produces distinct, but clustered and fragile isidia. *P. tyrrhea* also differs chemically from the latter lichen, containing hypostictic, hyposalazinic, stictic, hypoconstictic and constictic acids in the medulla. In contrast, *P. geckonalis* contains salazinic acid and the "chalybaeizans unknown" there.

## NOTES AND NEW RECORDS

**BULLATINA MICROCARPA** (Vezda) Brusse, *comb. nov.*

Basionym: *Calenia microcarpa* Vezda, Folia Geobot. Phytotax. **14**: 55. 1979.

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): **-BD** (Dwesa) Dwesa Nature Reserve. About 1 km from campsite on road to mPume gate. On living leaves of *Buxus natalensis* (Oliv.) Hutch. in understorey vegetation of coastal forest. Alt. 40 m. *F. Brusse 5644*, 10. i. 1990 (**BM, PRE**). Conf. A. Vezda.

This is the first record of this lichen for the African continent, being previously only known from Australia. It is clearly not a *Calenia*, and is here combined into *Bullatina*, where it is better accommodated.

**Cladonia (Cladina) portentosa** (Duf.) Coëm.

SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-AC** (Bain's Kloof) Hawequa's Mountains, east of Paarl. Hugenootskop. On soil, at base of Restioid reed clump near rock, on E slope. Alt. 1040 m. *F. Brusse 6219*, 03. xii. 1991 (**BM, CTES, H, LD, NDA, PRE, UPS**).

This seems to be a cosmopolitan species in mediterranean and sub-mediterranean climates, but I have not seen a specimen cited from subsaharan Africa.

*CLIOSTOMUM FLAVUM* (Zahlbr.) Brusse, *comb. nov.*

Basionym: *Toninia flava* Zahlbr., Ann. Crypt. Exot. **5**: 240. 1932. (Isotype: *P. van der Bijl 540*, **PREM**!).

This lichen seems to be endemic to the Saldanha Bay area of the south-western Cape, and a second collection of this rare lichen has been made at Cape Columbine (*F. Brusse 2926*, **COLO, PRE**). Both collections are from granite/gneiss. This species contains 4-O-methylcryptochlorophaeic acid as the main medullary metabolite, and there is some evidence that the minor metabolite is merochlorophaeic acid. There is another substance in this lichen that resembles atranorin on TLC plates A, B', C, G, and F.

Timdal (1991) stated that the holotype of this lichen was not found at **W**. Fortunately, an isotype still exists in the P. A. van der Bijl collection now housed at **PREM**, and this would have to be selected as the lectotype, in accordance with the rules for typification in the ICBN, should the absence of the holotype be confirmed. See under *Parmelia erebea* above for further information on the P. A. van der Bijl collection now at **PREM**.

The spermatia of this lichen are small, hyaline, pyriform to ovate, 2.8 - 3.7 X 1.2 - 1.9 $\mu$m, and are born acrogenously, from clearly phialidic spermatiophores. The ascus apex is of the Bacidia-type and this lichen therefore clearly belongs to the genus *Cliostomum* Fr. However, the epihymenium contains Bacidia-green, being an aeruginose colour, which is K- and dilute N+ pinkish. The type of *Cliostomum*, *Cl. corrugatum* (Ach.) Fr. lacks this Bacidia-green pigment in the epihymenium.

**Hypogymnia bitteri** (Lynge) Ahti

SOUTH AFRICA, CAPE PROVINCE - **3219** (Wuppertal): **-AC** (Wuppertal) Cedarberg Table Mountain near Clanwilliam. SW cliffs opposite "the spout". On Table Mountain Sandstone in slightly protected position near overhang at base of SW summit cliffs. Alt. 1880 m. *F. Brusse 6070*, 19. xi. 1991 (**PRE**).

This species has previously been recorded from East Africa (Swinscow & Krog 1988), and is well known in the Northern Hemisphere. This record extends its range to the mountains of the SW Cape at high altitudes.

**Imshaugia aleurites** (Ach.) S. L. Fricke Meyer

SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-AD** (Ceres) NW end of Waaihoek Mountains. Summit of the lower Mosterthoek Twin. On SW side of Table Mountain Sandstone rock, growing over *Lasallia papulosa* and adjacent rock. Alt. 1940 m. *F. Brusse 6126*, 24. xi. 1991 (**PRE**).

This is a new record for southern Africa, but has previously been recorded from East Africa (Swinscow & Krog 1988). It is cosmopolitan in cold alpine and arctic areas. The cited specimen contains thamnolic (maj.) and baeomycesic (min.) acids. A trace of decarboxythamnolic acid is perhaps an artifact of the TLC procedure. No atranorin is present.

The names *Lichen pallescens* Neck. and *Lichen diffusus* Web. will still have to be carefully typified, before stability in nomenclature can be achieved for the species in this genus and *Parmeliopsis* Nyl.

**Megalospora sulphurata** Meyen var. **nigricans** (Müll. Arg.) Riddle

SOUTH AFRICA, TRANSVAAL - **2430** (Pilgrim's Rest): **-DD** (Graskop) Graskop, forest relic in ravine behind Municipal Caravan Park. Alt. 1450 m. *H. Sipman 20048*, 15. i. 1986 (**B, PRE**).

This variety has recently been reported for the Old World from Madagascar (Sipman 1986). It had previously only been recorded from the New World (Sipman 1983). This record extends the range of this variety to mainland Africa.

*Parmelia festiva* Brusse, Mycotaxon **36**: 305. 1989.

The description of this species was based on a mixture of two lichens, i.e. based on discordant elements (Brusse 1989). As mentioned by Brusse (1991), the second lichen is probably *Arthrorhaphis citrinella* (Ach.) Poelt. This second lichen, which was originally thought to be the soralia of the foliose lichen, is hereby explicitly excluded from the application of the name *Parmelia festiva* Brusse.

The name *Xanthoparmelia olivetorica* Hale (1986) was not explicitly typified by Hale (1990), instead a different collection number, the paratype (*Hale 72080*), was indicated as holotype, in place of the one originally cited as such (*Hale 72079*). The possibility of a printing error does not arise here, because of the involvement of two digits in the collector's numbers. The use of the epithet "*olivetorica*" for a lichen that contains gyrophoric acid, is confusing.

*Parmelia pustulescens* Kurok.

The chemistry of this lichen has recently been re-examined and found to contain ramalinolic acid as the major medullary substance, the commonly reported sekikaic acid occurs only in minor to trace amounts. Echinocarpic acid is an accessory substance in this species, and is sometimes not present.

*PARMELIA PUTSOA* (Hale) Brusse, *comb. nov.*

Basionym: *Xanthoparmelia putsoa* Hale, Mycotaxon **30**: 328. 1987.

LESOTHO - **2828** (Bethlehem): **-DD** (Mont-aux-Sources) Natal Drakensberg. 37 km S of Phuthaditjhaba. On basalt rock on SE side of Mont-aux-Sources peak. Alt. 3270 m. *F. Brusse 5893*, 30. iii. 1991 (**LD, PRE**).

This species was originally thought to contain gyrophoric acid, but a TLC examination of this new material shows this not to be so. The revised chemistry of this lichen is therefore: usnic, echinocarpic, conechinocarpic (min./tr.) acids and an unidentified substance, which does not smear or trail on TLC plates like gyrophoric acid does. This lichen was previously thought to be a variant of *P. gyrophorica* (Hale) Brusse, which does contain gyrophoric acid (without echinocarpic acid) in the medulla.

**Parmelia saxatilis** (L.) Ach.

SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): **-AD** (Ceres) NW end of Waaihoek Mountains. Summit of the lower Mosterthoek Twin, between Ceres and Wolseley. On floor of rock hollow, at base of small SW Table Mountain Sandstone cliff at summit. Alt. 1940 m. *F. Brusse 6100*, 25. xi. 1991 (**BM, LD, PRE**); **-DA** (Nuy) Summit of Keerom Mountain near Worcester. On S to SE Table Mountain Sandstone rock. Alt. 2070 m. *F. Brusse 6205*, 01. xii. 1991 (**LD, PRE**).

This is the first time that this well known lichen has been correctly recorded from southern Africa. It seems to occur only on high peaks in the Cape Fold Mountains. *P. saxatilis* has also been detected at the Cedarberg Table Mountain, but the material is too scrappy to cite.

**Phaeophyscia confusa** Mob.

NAMIBIA - **1916** (Gobaub): **-DD**, Farm Boshoek GR 81, SW of Otavi. On bark of *Acacia mellifera* ssp. *detinens*. *O. H. Volk 81/184*, 15. ii. 1981 (**PRE**).

This species was described as new from East Africa (Moberg 1983), and is now reported for the flora of southern Africa.

**Porpidia soredizodes** (Lamy) Laund.

SOUTH AFRICA, QWAQWA - **2828** (Bethlehem): **-DB** (Witsieshoek) 33 km S of Phuthaditjhaba, on path to Mont-aux-Sources via chain ladder. Western slopes of the Sentinel. On basalt outcrops with steep to vertical W faces. Alt. 2800 m. *F. Brusse 5899*, 31. iii. 1991 (**M, PRE**).

This species has previously been recorded in the Southern Hemisphere from Australia (Rambold 1989), and is here newly reported from Africa, south of the Sahara.

**Toninia aromatica** (Sm.) Massal.

SOUTH AFRICA, CAPE PROVINCE - **3419** (Caledon): **-CB** (Gansbaai) Byneskranskop near Strandskloof overlooking the Uilkraal river valley. On a SE sandy limestone kranz. Alt. 50 m. *F. Brusse 3840*, 14. v. 1981 (**PRE**). Conf. E. Timdal 1992.

- **3420** (Bredasdorp): **-CA** (Bredasdorp) Mierkraal. Die Poort in Heuningnes River valley. On a S facing limestone kranz. Alt. 50 m. *F. Brusse 3820*, 14. v. 1981 (**PRE**). Conf. E. Timdal 1992.

The recent monograph on *Toninia* (Timdal 1991), recorded this lichen in the Southern Hemisphere only from Australasia. These two new records extend the distribution to austral Africa as well.

**Toninia cinereovirens** (Schaer.) Massal.

SOUTH AFRICA, ORANGE FREE STATE - **2828** (Bethlehem): **-AD** (Jordaanrivier) Saaihoek, between Bethlehem and Clarens. *Dr. Pont & Dr. van Elden 1942*, 13. ix. 1943 (**PRE**). Det. E. Timdal 1992.

This is a new record for southern Africa, although this species is already known from eastern Africa (Timdal 1991).

*Toninia lutosa* (Ach.) Timdal

When the *Toninia* revision appeared (Timdal 1991) it became clear that the specimen cited as *Toninia toniniana* (Massal) Zahlbr. by Brusse (1991) was not in fact this species, but *T. lutosa*. *T. lutosa* has previously been reported from Namibia (as *Catillaria crystallifera* Kilias) and the Brusse (1991) record thus serves as a citation for South Africa. *T. toniniana* is only known from Europe (Timdal 1991).

*Trapelia rediviva* Brusse

In figure 7 of the original description of this species (Brusse 1991b), the guttules in the ascospores are figured as being of much smaller diameter than the breadth of the ascospores. This is actually an artifact, because in fresh sections the guttules are of the same diameter as the width of the ascospores.

## ACKNOWLEDGEMENTS

I am thankful to Prof. J. A. Elix (Canberra) for reviewing this paper. The examination of type and other valuable material from **B**, **BM**, **COLO**, **FH**, **G**, **GLAM**, **H**, **LD**, **TNS**, **TRH**, **TUR**, **US**, **VER**, **W**, & **ZT**, has made this study possible. Mrs A. J. Romanowski is thanked for her darkroom expertise. The author is also grateful for co-operation from forest officers at the Cedarberg Wilderness Area, Hawequa's Forest Reserve, Grootvader's Forest Reserve, and several private landowners who kindly allowed the author to look for lichens on their properties. The author is especially grateful to the South African Ski Club (Cape Town) for permission to use their luxurious Peak Hut on the summit of Matroos Mountain. Thanks are also extended to Dr. H. Sipman (Berlin) for allowing me to cite his specimens in this paper.

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FIGURE 5. - *Parmelia antedeluvialis* Brusse & Sipman, habit. *H. Sipman 19906*, holotype. Scale in mm & cm.

FIGURE 6. - *Parmelia diutina* Brusse, habit. *F. Brusse 6296*, holotype. Scale in mm.

FIGURE 7. - *Parmelia epacridea* Brusse, habit. *F. Brusse 6065*, holotype. Scale in mm.

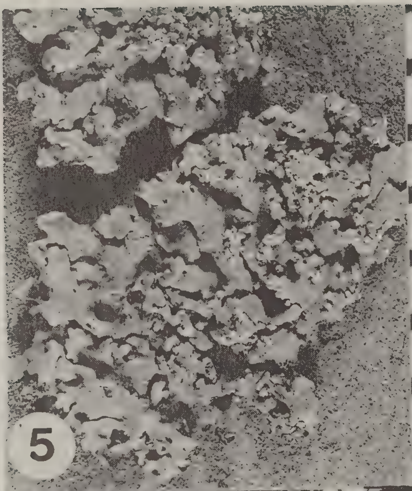
FIGURE 8. - *Parmelia erebea* Brusse, habit. *P. A. van der Bijl 760(b)*, holotype. Scale in mm.

FIGURE 9. - *Parmelia manina* Brusse, habit. *F. Brusse 6085*, holotype. Scale in mm.

FIGURE 10. - *Parmelia nautilomontana* Brusse, habit. *F. Brusse 6152*, holotype. Scale in mm & cm.

FIGURE 11. - *Parmelia pristiloba* Brusse, habit. *F. Brusse 6017*, holotype. Scale in mm.

FIGURE 12. - *Parmelia tyrrhea* Brusse, habit. *F. Brusse 6064*, holotype. Scale in mm.



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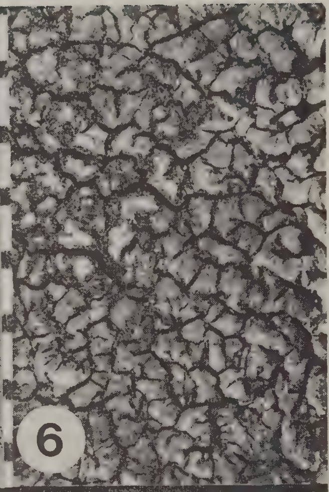

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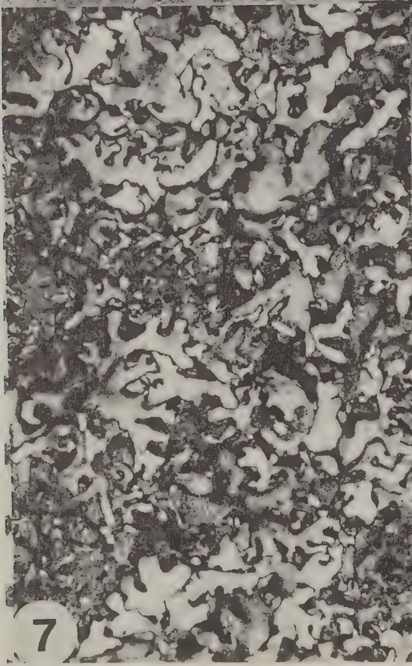

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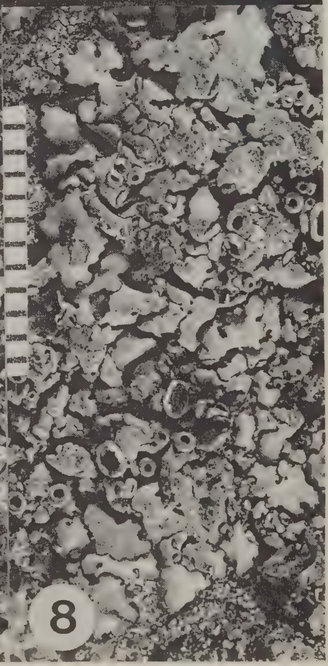

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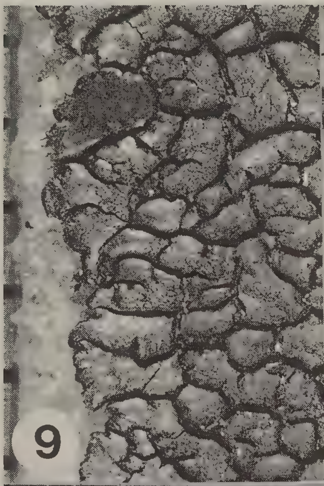
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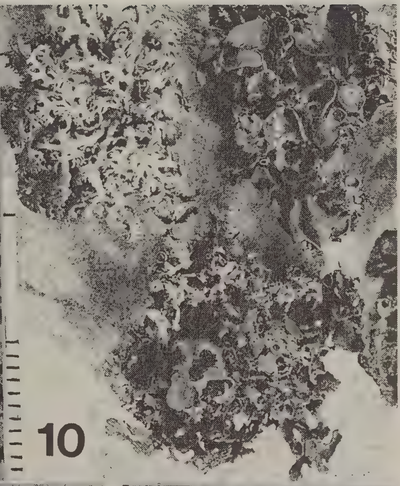
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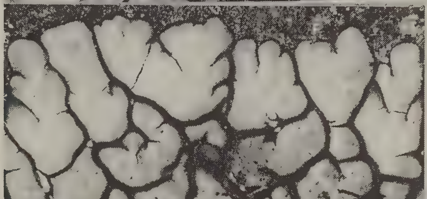
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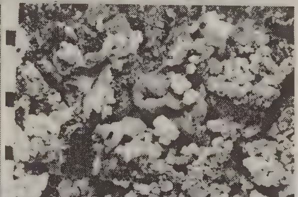
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# TWENTY-FIVE NEW CONIDIAL FUNGI FROM THE WESTERN GHATS AND THE ANDAMAN ISLANDS (INDIA)

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ABSTRACT — Twenty-five new taxa of conidial fungi are described and illustrated from forest litter in the Western Ghats in southern India, and from the Andaman Islands. They include the new anamorph-genera *Vanakripa* and *Xenoheteroconium*, and new species of *Anavirga*, *Arthrinium*, *Bahusutrabeeja*, *Beltrania*, *Cheiropolyschema*, *Craspedodidymum*, *Cryptophiale*, *Dictyochaeta*, *Dischloridium*, *Fusichalara*, *Hyphopolynema*, *Kostermansinda*, *Phialosporostilbe*, *Phragmotrichum*, *Piricaudiopsis*, *Selenodriella*, *Spadicoides*, *Sporidesmiopsis*, *Sporoschisma* and *Uberispora*. In addition, new combinations are made in *Craspedodidymum*, *Dictyochaeta*, and *Sporidesmiopsis*.

KEY WORDS: anamorphs, conidial fungi, hyphomycetes, taxonomy, new taxa, biodiversity, India, litter decomposition.

## INTRODUCTION

During surveys of tropical microfungi from the forests of the Western Ghat hills in southwestern India, and from the Andaman Islands, numerous conidial fungi (dikaryomycotan anamorphs) were collected on plant litter. Among them were a substantial number of undescribed taxa.

This paper describes and illustrates 25 of these new taxa, as part of an ongoing documentation of previously unrecorded biodiversity in tropical microfungi (see Castañeda & Kendrick, 1990a,b, 1991).

### The Western Ghats and their forests.

The Western Ghats are an extensive range of hills in south-western India, running nearly parallel to the coastline between 8°— 22.5°N and 72.5°— 76.5°E, extending south from the Tapti river for about 1600 km through five States to Cape Comorin (Fig. 1). The steep western escarpment of the Ghats rises 15-80 km from the west coast, and the hills slope gently away to the east, the average elevation being 1220 m. The Western Ghats receive southwest monsoon rain from June to September. Annual rainfall on the western slopes ranges from 300 to 550 cm. Mean annual temperature is 28°C to 31°C, the temperature seldom falling below 15°C. Mean annual relative humidity is above 80%. Under these warm and humid conditions, luxuriant wet evergreen forests flourish on the windward, western side of the escarpments (Pascal, 1989). The mycota of this area is still largely unknown, but the senior author is collecting extensively and intensively, and we will explore the fungal facet of its biodiversity in a series of publications.

### The rainforests of the Andaman-Nicobar Islands.

The Andaman and Nicobar Islands are a string of about 350 islands (over 500 if one counts all the tiny outcrops) in the Bay of Bengal that form an archipelago 700 km long and 60 km wide, lying between 6° and 14°N, and 92° and 94° E, with a combined coastline of about 2000 km (Fig. 1). The interiors of these islands still support dense rainforests, while mangrove swamps fringe the coast. The islands have a hot, humid climate with temperatures ranging from 23°-36°C, relative humidity of 80-90%, and rainfall of 300-400 cm per year. The remoteness of the islands from the mainland and their relative inaccessibility helped to preserve the rainforests and mangroves. Although the flora of the Andaman and Nicobar Islands is said to be partly endemic and partly composed of elements from Burma and Malayasia, no authoritative reports have yet been published on the fungi of these islands. In this series of papers, we hope to partially remedy this deficiency.

### Studies of microfungi in Asia

Many new taxa of hyphomycetes have already been described from south and south-east Asia by Kuthubutheen and Nawawi (1991a,b,c,d,e, 1992), Matsushima (1971, 1975, 1980, 1981, 1983, 1989), Nawawi and Kuthubutheen (1988, 1989a,b, 1990, 1992), Pirozynski and Patil (1970),

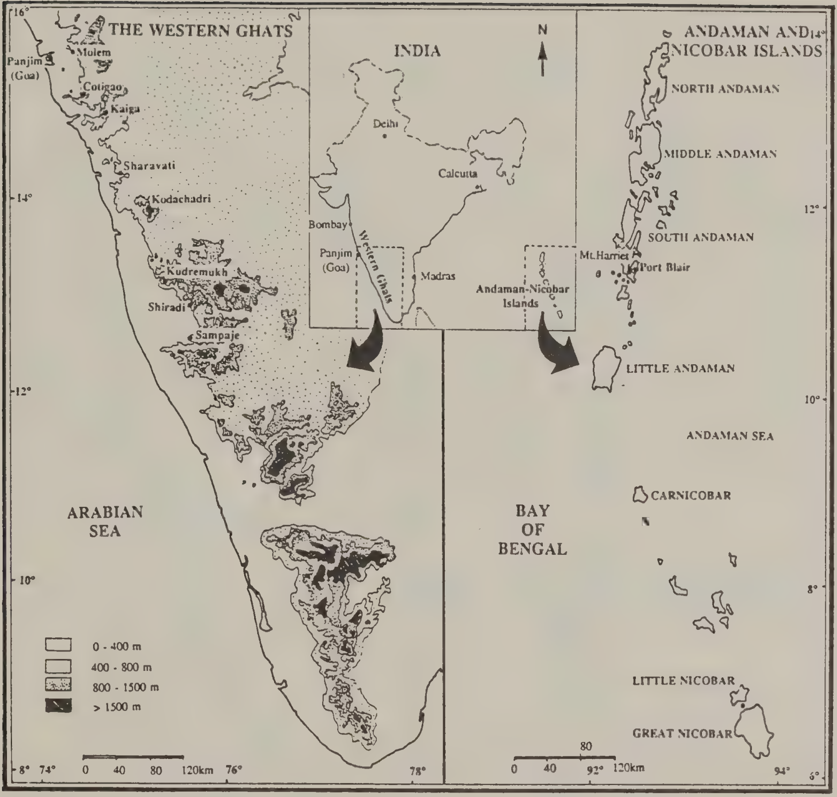
THE WESTERN GHATS
16°
Panjim (Goa)
Molem
Cotigao
Kaiga
Sharavati
14°
Kodachadri
Kudremukh
Shiradi
Sampaje
12°
ARABIAN SEA
10°
0 - 400 m
400 - 800 m
800 - 1500 m
> 1500 m
8° 74°
0 40 80 120km 76°
78°
INDIA
N
Delhi
Calcutta
Bombay
Panjim (Goa)
Western Ghats
Madras
Andaman-Nicobar Islands
ANDAMAN AND NICOBAR ISLANDS
14°
NORTH ANDAMAN
MIDDLE ANDAMAN
12°
SOUTH ANDAMAN
Mt.Harriet
Port Blair
LITTLE ANDAMAN
10°
ANDAMAN SEA
BAY OF BENGAL
CARNICOBAR
8°
LITTLE NICOBAR
GREAT NICOBAR
80
0 40 92° 120km
94°
6°

Fig. 1. Map of the Western Ghats of south-west India, and the Andaman Islands.

Rao and de Hoog (1986), Subramanian and Bhat (1977, 1987), Tzean and Chen (1989a,b,c, 1990, 1991) and Tzean et al. (1990). However, according to present estimates (Hawksworth, 1991) we have so far described less than 5% of the world's mycota. The fungi of tropical regions are especially poorly known. The present study was undertaken to add to our knowledge of Asian microfungi

## MATERIALS AND METHODS

Throughout this study, lactic acid and lactophenol mounting media were used in making semi-permanent slide preparations. Measurements were made in lactic acid mounts. Drawings were executed with the aid of a camera lucida.

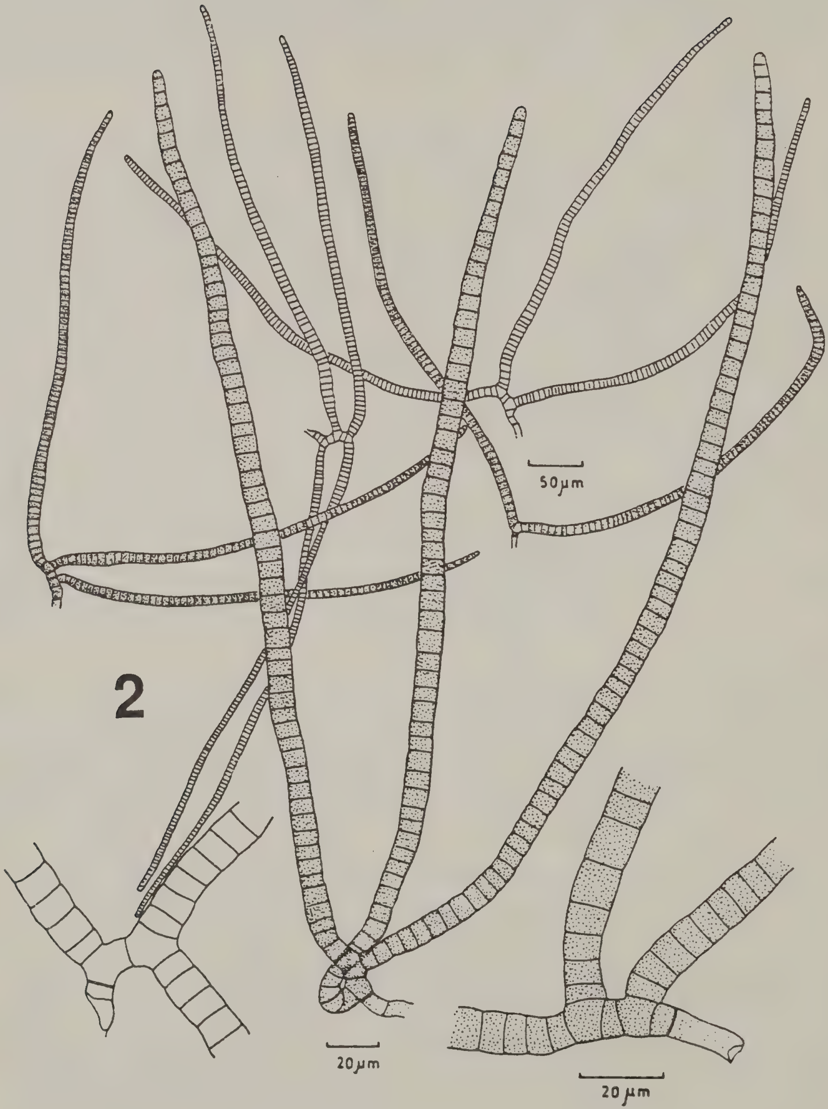
50 μm
2
20 μm
20 μm

Fig. 2. *Anavirga vermiformis* anam.-sp. nov. staurospores with worm-like arms.

## TAXONOMY

***Anavirga vermiformis*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 2)
(Etym. Latin: *vermis* = a worm + *forma* = shape)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae, velutinae. Mycelium partim superficiale, partim in substrato immersum, ex hyphis laevibus, pallide brunneis, ramosis, septatis, 3.5-4.5 µm lat. compositum. Conidiophora inconspicua, mononemata, 1-2-septata, valde pallide brunnea, laevia, usque ad 10 µm long. et usque ad 5 µm lat. Cellulae conidiogenae integratae, terminales, determinatae. Conidia sicca, laevia, ramosa, brachiis 2-4 (vulgo 3), longissimis, divergentibus, ex cellulis successivis axis principalis perpendiculariter exorientibus; unumquidque brachium vermiforme et flexuosum, 300-400 µm long., 7-9.5 µm lat., 60-120-euseptatum, ad aliquot septa leniter constrictum, brunneum vel aureo-brunneum, laeve, ad apicem rotundatum leniter angustatum.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown, velvety. Mycelium partly superficial, partly immersed in the substrate, composed of smooth, pale brown, branched, septate hyphae 3.5-4.5 µm wide. Conidiophores inconspicuous, mononematous, 1-2-septate, very pale brown, smooth, up to 10 µm long, up to 5 µm wide. Conidiogenous cells integrated, terminal, determinate. Conidia dry, smooth, branched, with 2-4 (mostly 3) very long divergent arms arising at right angles from successive cells of the main axis; each arm vermiform and flexuous, 300-400 µm long, 7-9.5 µm wide, 60-120-euseptate, slightly constricted at some septa, brown to golden brown, smooth, slightly narrower at the rounded apex.
HOLOTYPE: on dead twigs, Kodachadri Hills, Karnataka State, India, 12 Sept. 1991, D.J. Bhat, DAOM 214620.
Teleomorph: unknown.

Although the generic limits of those conidial fungi with branched, hyphoid conidia are not yet well defined, our fungus can best be accommodated in *Anavirga* Sutton (Sutton, 1975). The conidia of *A. vermiformis* are clearly different from those of the two known species [*A. laxa* Sutton (1975) and *A. dendromorpha* Descals & Sutton (1976)]. The conidia in *A. laxa* are triradiate (Y-shaped) or occasionally tetraradiate, 4-16-septate and 90-185 X 11-14 µm; in *A. dendromorpha*, the conidia may branch at any point along their axis (not exclusively near the base, as in *A. vermiformis*); they may also assume a densely arborescent form and give rise to an unnamed *Phialocephala* synanamorph. In our opinion, the *Phialocephala* synanamorph of *A. dendromorpha* is the more characteristic and differentiated of the two anamorphs, and not only fully deserves a binomial, but should probably be given preference as the diagnostic anamorph.

***Arthrinium mytilomorphum*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 3)
(Etym. Greek: *mytilos* = mussel + *morphe* = shape)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae punctiformes, pulvinatae, atrobrunneae, hypophyllae. Conidiophora basauxica, mononematica, erecta, flexuosa, cylindrica, incolorata, apice rotundato, usque ad 80 µm alt., 4.5-5 µm lat., septis conspicuis, spissis, atro-brunneis praedita, e cellulis matricalibus obpyriformibus vel ampulliformibus basibus brunneis apicibus incoloratis, 5.5-6.5 µm lat. oriunda. Cellulae conidiogenae integratae, terminales vel intercalares, mono- vel polyblasticae, minute denticulatae, 9-10 X 4.5-5 µm. Conidia solitaria, sicca, fusiformia vel navicularia, leniter curva et asymmetrica, non-septata (amerospora), laevia, ad medium latissima, sed versus extremitates anguste rotundatas attenuata, 20-30 X 6-8.5 µm; pars proximalis per tres longitudinis quadrantes atro-brunnea, pars distalis per unum longitudinis quadrantem pallide brunnea et leniter per frontem aspera, inter quas est zona angusta paene incolorata; locus affixus in parte conidii media convexa fuscata perspicue visibilis.

Conidial fungi, hyphomycetes. Colonies punctiform, pulvinate, dark brown, hypophyllous. Conidiophores basauxic, mononematous, erect, flexuous, cylindrical, colourless, rounded at the apex, up to 80 µm tall, 4.5-5 µm wide, with conspicuous thick, dark brown septa; arising from obpyriform to ampulliform conidiophore mother cells that are brown at the base and colourless at the apex, 5.5-6.5 µm wide. Conidiogenous cells integrated, terminal or intercalary, mono- to poly-blastic, minutely denticulate, 9-10 X 4.5-5 µm. Conidia solitary, dry, fusiform to navicular, slightly curved and asymmetrical, non-septate (amerosporous), smooth-walled, broadest in the middle, tapering toward the narrowly rounded ends, 20-30 X 6-8.5 µm, proximal three-quarters dark brown, distal quarter pale brown and slightly roughened on the face, with a narrow, almost colourless zone between the lighter and darker parts; point of attachment clearly visible at the mid point of the convex dark region of the conidium. HOLOTYPE: on dead blades of *Andropogon* sp. (Poaceae), Kodachadri Hills, Dakshina Kannada District, Karnataka State, India, 12 Dec. 1991, D.J. Bhat, DAOM 214595.

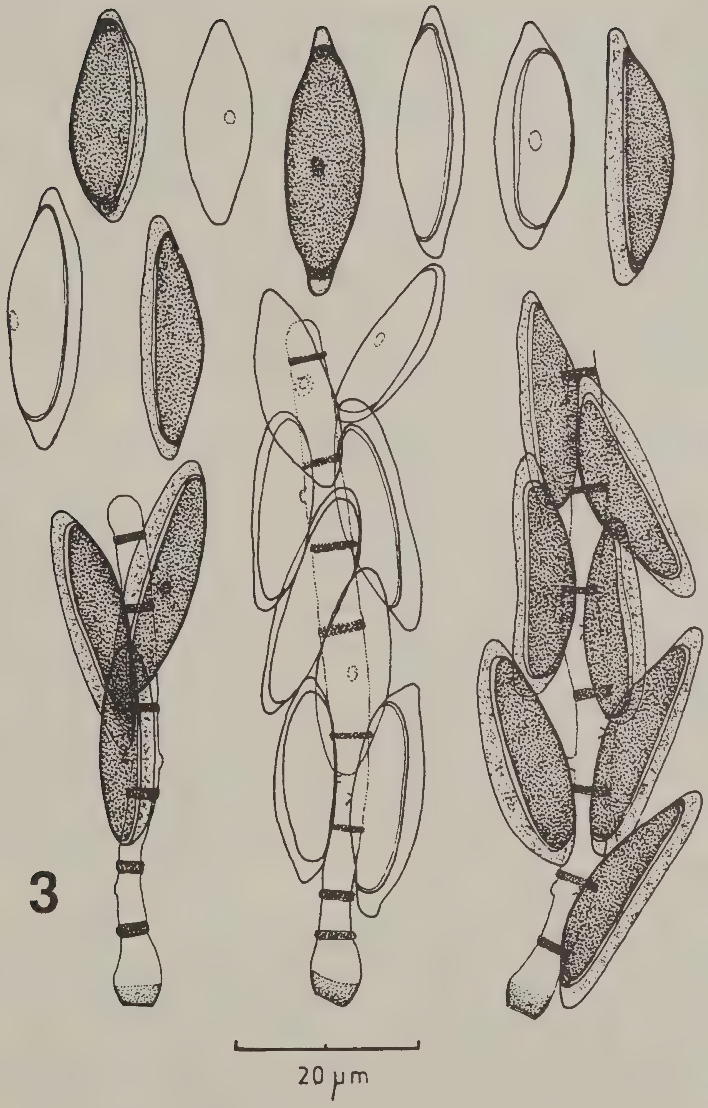

Fig. 3. *Arthrinium mytilomorphum* anam.-sp. nov. three basauxic conidiophores and clam-shaped conidia.

Teleomorph: unknown.

Because of the distinctive morphology of its conidia, our new species need be compared with only two of the previously described species of *Arthrinium*. The conidia in *A. ushuvaiense* Spegazzini (Ellis, 1971) are only 17-25 X 6-9 µm and are uniformly darkly pigmented, except for a narrow, distal (or peripheral) colourless rim or germ slit. In *A. caricicola* Kunze ex Ficinus & Schubert (Ellis, 1971), the conidia are larger, 30-53 X 7.5-13 µm, and although their pattern of pigmentation is superficially similar to that in *A. mytilomorphum*, the narrow colourless zone is distal, while in *A. mytilomorphum* the corresponding colourless zone is median. The strange, elongate sterile cells (they may be aborted conidia) that arise from the conidiophore axis alongside the conidia of *A. caricicola* and *A. ushuvaiense* are absent from *A. mytilomorphum*.

***Bahusutrabeeja globosa*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 4)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae, velutinae. Conidiophora mononematica, erecta, recta vel flexuosa, non-ramosa, usque ad 350 µm alt., 7.5-9.5 µm lat., percurrenter renascentia, 5-12-septata, ad basim inflatam atrobrunnea, apicem versus pallescentia. Cellulae conidiogenae terminales, integratae, monophialidicae, basim versus leniter inflatae, 25-32 X 8-9.5 µm, apertura phialidis 5.5 µm lat., cum collarulo brevissimo, inconspicuo, parum expanso. Conidia blastico-phialidica, globosa ad apicem phialidis in massa mucosa hyalina aggregata, crassitunicata, non-septata, incolorata cum cytoplasmate granuloso, 18-22 µm diam., setulis 9-12, gracilibus, radiantibus, 6.5-12.5 µm long., per superficiem aequabiliter dispositis praedita.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown, velvety. Conidiophores mononematous, erect, straight or flexuous, unbranched, up to 350 µm long, 7.5-9.5 µm wide, regenerating percurrently, 5-12-septate, dark brown at the swollen base, slightly paler toward the apex. Conidiogenous cells terminal, integrated, monophialidic, slightly swollen toward the base, 25-32 X 8-9.5 µm, phialide opening 5.5 µm wide, with a very short, inconspicuous, slightly flaring collarette. Conidia blastic-phialidic, globose, accumulating in a slimy colourless mass at the apex of the phialide, thick-walled, non-septate, colourless with granular cytoplasm, 18-22 µm diam., with 9-12 slender, radiating setulae, 6.5-12.5 µm long, distributed evenly over the surface of the conidia.
HOLOTYPE: on decaying twigs, Kudremukh, Karnataka State, India, 2

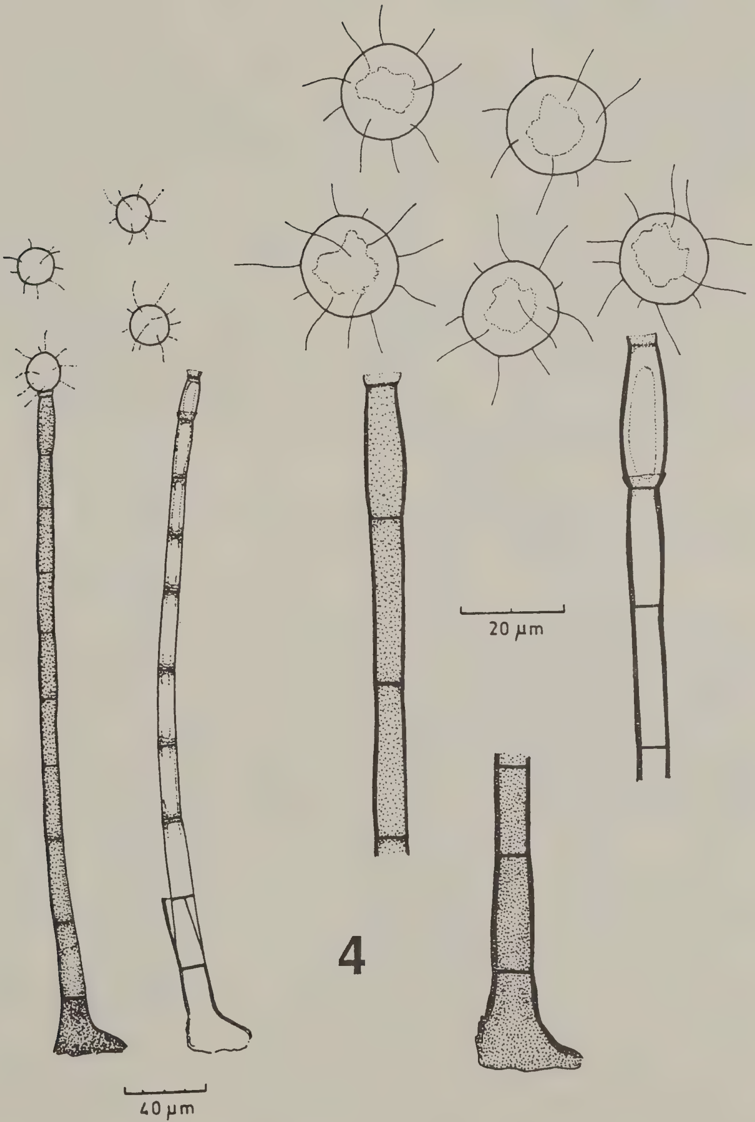

Fig. 4. *Bahusutrabeeja globosa* anam.-sp. nov.: conidiophores and globose, multi-setulate conidia.

July 1989, D.J. Bhat, DAOM 214596.
Teleomorph: unknown.

In the type species of the genus *Bahusutrabeeja* Subramanian & Bhat, *B. dwaya* Subramanian & Bhat (1977), the first-formed conidia are pear-shaped, while subsequent conidia are globose and smaller. In *B. globosa*, conidia are globose and larger than those of *B. dwaya*. The globose conidia of *B. dwaya* are 12.5-14(-16) µm in diam., while in *B. globosa* they are 18-22 µm diam. This means that conidia of *B. globosa* have almost three times the volume of those of *B. dwaya*. The conidial setulae of *B. dwaya* are 4.5-5 µm long, whereas in *B. globosa* they are 6.5-12.5 µm long. The only other species of *Bahusutrabeeja*, *B. angularis* Rao & de Hoog (1986) has much smaller, angular conidia, appearing 4- or 5-sided, 7-8 µm in diam., with a setula arising from each corner, and with a narrow truncate base.

***Beltrania circinata*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 5)
(Etym. Latin: *circinatus* = made circular)

Ad fungos conidiales, hyphomycetes, pertinet. Coloniae effusae, leniter prominentes, olivaceae vel atrobrunneae, velutinae, hypophyllae. Conidiophora mononematica, 2-6 aggregata, erecta, recta vel flexuosa, crassitunicata, 50-110 µm alt., cellula basali inflata et lobata, 9.5-11.5 µm lat., stipite 4.5-6 µm lat. supra basim, gradualiter dilatato ad 8.5 µm apicem versus, 3-5-septata, non-ramosa; pars inferior laevis et brunnea, pars superior verrucosa et atrobrunnea. Setae numerosae, non-ramosae, erectae, in parte superiore flexuosae, sinuatae, valde curvatae vel circinatae, crassitunicatae, 130-290 µm alt., 4-7-septatae, cellula basali lobata et usque ad 10.5 µm lat., axe 4-6 µm lat. supra basim, attenuato ad 2.5-3 µm lat. apicem versus, infra laeviae et brunneae, supra verrucosae et atrobrunneae. Cellulae conidiogenae terminales, discretae, usque ad 10, verticillatim vel fasciculate ad apicem conidiophori, polyblasticae, globosae vel subglobosae, plerumque non-septatae, interdum 1-septatae, 7-8.5 µm diam., crassitunicatae, laeves, brunneae vel atrobrunneae, 1-4-denticulatae, constrictae ad basim. Conidia sicca, biconica, laevia, non-septata, crassitunicata, brunnea vel atrobrunnea, cum zona aequatoria paene incolorata vel pallide brunnea, margine irregulari, 1.5-2 µm lat., valde contracta et minute rostrata ad apicem, rotundata ad basim, 16-22.5 X 10-12 µm.

Conidial fungi, hyphomycetes. Colonies effuse, slightly raised, olivaceous to dark brown, velvety, hypophyllous. Conidiophores mononematous,

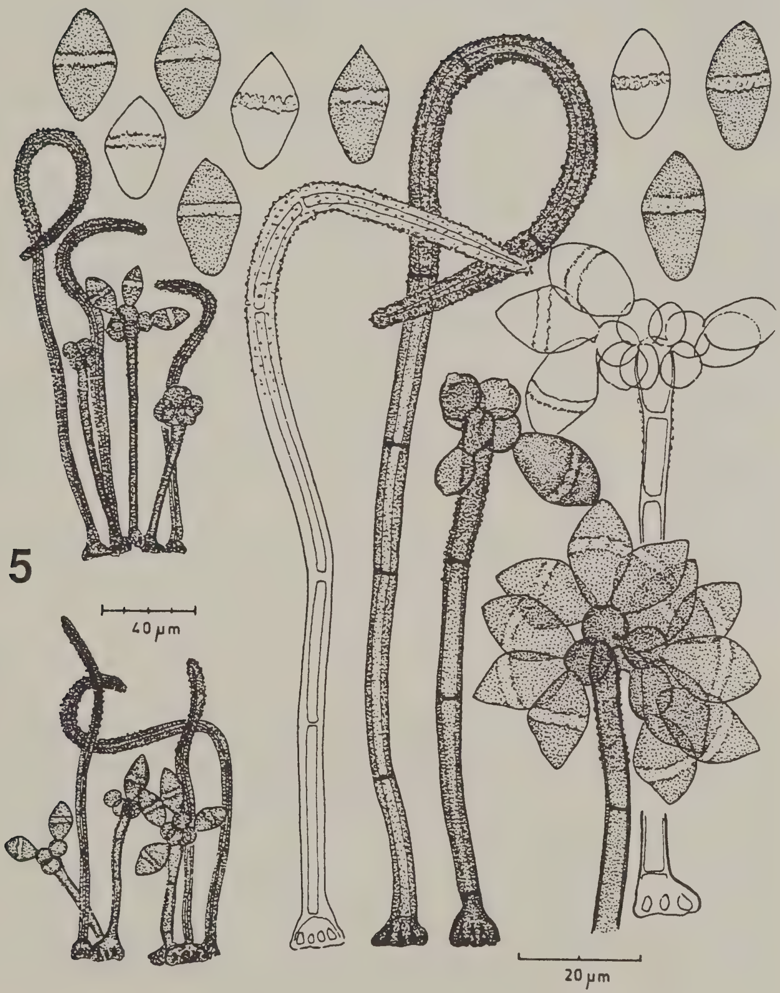

Fig. 5. *Beltrania circinata* anam.-sp. nov.: circinate setae, conidiophores and biconic conidia.

arising in groups of 2-6, erect, straight or flexuous, thick-walled, 50-110 µm long, inflated and lobed basal cell 9.5-11.5 µm wide, stipe 4.5-6 µm wide above base, widening gradually to 8.5 µm near the apex, 3-5-septate, unbranched; lower part of conidiophores smooth and medium brown, upper part verrucose and dark brown. Setae numerous, unbranched, erect, upper part flexuous, sinuate, strongly curved or circinate, thick-walled, 130-290 µm long, 4-7-septate, basal cell lobed and up to 10.5 µm wide, axis 4-6 µm wide above the base, tapering to 2.5-3 µm wide at the apex, lower half smooth and medium brown, upper half verrucose and dark brown. Conidiogenous cells terminal, discrete, up to 10, developing in whorls or clusters at the conidiophore apex, polyblastic, globose to subglobose, usually non-septate, occasionally 1-septate, 7-8.5 µm diam., thick-walled, smooth, medium to dark brown, 1-4-denticulate, deeply constricted at the base. Conidia solitary, dry, biconic, smooth, non-septate, thick-walled, medium to dark brown, with an almost colourless to pale brown, irregularly edged equatorial band, 1.5-2 µm wide; sharply tapering and minutely beaked at the tip, rounded at the base, 16-22.5 X 10-12 µm.
HOLOTYPE: on decaying leaves of *Terminalia* sp. (Combretaceae), western escarpment of the Kodachadri hills, Dakshina Kannada District, Karnataka State, India, 30 Dec. 1989, D.J. Bhat, DAOM 214597.

Of all known species of *Beltrania* Penzig (Ellis, 1976; Matsushima, 1975; Pirozynski, 1963; Pirozynski and Patil, 1970), verrucose setae are found only in *B. africana* Hughes and *B. mangifera* Manjal and Kapoor. In *B. africana*, the sparsely verrucose setae are straight, and the conidia are very large, 35-45 X 17-20 µm. In *B. mangifera*, setae are of two kinds, both arising from the same radially lobed basal cell: a single central straight, smooth, dark brown, pointed seta surrounded by 2-5 flexuous, pale brown, narrower and slightly taller setae with the upper half distinctly verrucose. In *B. circinata*, all setae are verrucose and apically circinate. *B. onirica* Onofri *et al.* (1981) has smooth, straight setae, and its conidia lack a clearly defined equatorial band.

In a revision of *Beltrania* and related genera, Pirozynski (1963) described the conidiogenous cells as integrated, polyblastic and often associated with almost colourless to pale brown, thin-walled, oval to subglobose, separating cells that usually become detached with the conidia. Subsequent workers have seen these separating cells attached to conidia in all known species of *Beltrania*. It seems possible that the discrete, non-caducous conidiogenous cells of *B. circinata* may be derived from the so-called 'separating cells.' Although this character makes *B. circinata* distinct from the rest of the genus, we do not consider it an adequate reason for disposing this species elsewhere, since its other features are typical of *Beltrania.*

***Cheiropolyschema ghaticum*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 6)
(Etym. Hindi: *ghat* = escarpment)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae vel nigrae. Conidiophora mononematica, erecta vel prostrata, flexuosa, pallide brunnea vel brunnea, usque ad 30 µm alt., saepe ramos breves fertiles ferentia; rami arcte septati, ad septa constricti, torulosi, cellula unaquaeque globosa vel subglobosa, laevis, 3.5-5 µm diam. Cellulae conidiogenae integratae, terminales, monoblasticae, globosae, brunneae usque atrobrunneae, post secessionem conidiorum cupulatae, 4.5-5.5 µm diam. Conidia solitaria, sicca, olivacea vel atrobrunnea, aspectu muriformia (dictyoseptata) sed re vera cheirosporosa, complanata, 12-23 X 10.5-14 µm, semper ex seriebus tribus cellularum contiguis, seriebus externis ad apicem saepe incurvatis; series unaquaeque vulgo ex 3-4 cellulis aequalibus, sed alterum latus interdum brevius quam alterum; cellulae plerumque rectangulares, 4-5 µm diam., cellulae apicales plerumque utrinque rotundatae; cellulae omnino 10-13; cellulae conidiogenae interdum cum socio conidio secedentes.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown to black. Conidiophores mononematous, erect to prostrate, flexuous, pale to medium brown, up to 30 µm long, often bearing short fertile branches, closely septate, deeply constricted at the septa, torulose, each cell globose to subglobose, smooth, 3.5-5 µm diam. Conidiogenous cells integrated, terminal, monoblastic, globose, medium to dark brown, becoming cupulate after conidium secession, 4.5-5.5 µm diam. Conidia solitary, dry, olive-brown to dark brown, appearing dictyoseptate but actually cheirosporous (hand-like), flattened in one plane, 12-23 X 10.5-14 µm, always with 3 contiguous rows of cells, outer rows often apically incurved; each row usually with 3-4 cells of equal length, but the row on one side occasionally shorter than that on the other; cells mostly rectangular, 4-5 µm diam., apical cells often with rounded ends; total number of cells per conidium 10-13; conidiogenous cell sometimes seceding with conidium and remaining attached at its base.
HOLOTYPE: on decaying leaves, Edakumeri, Dakshina Kannada District, Karnataka State, India, 29 Sept. 1989, D.J. Bhat, DAOM 214602.
Teleomorph: unknown.

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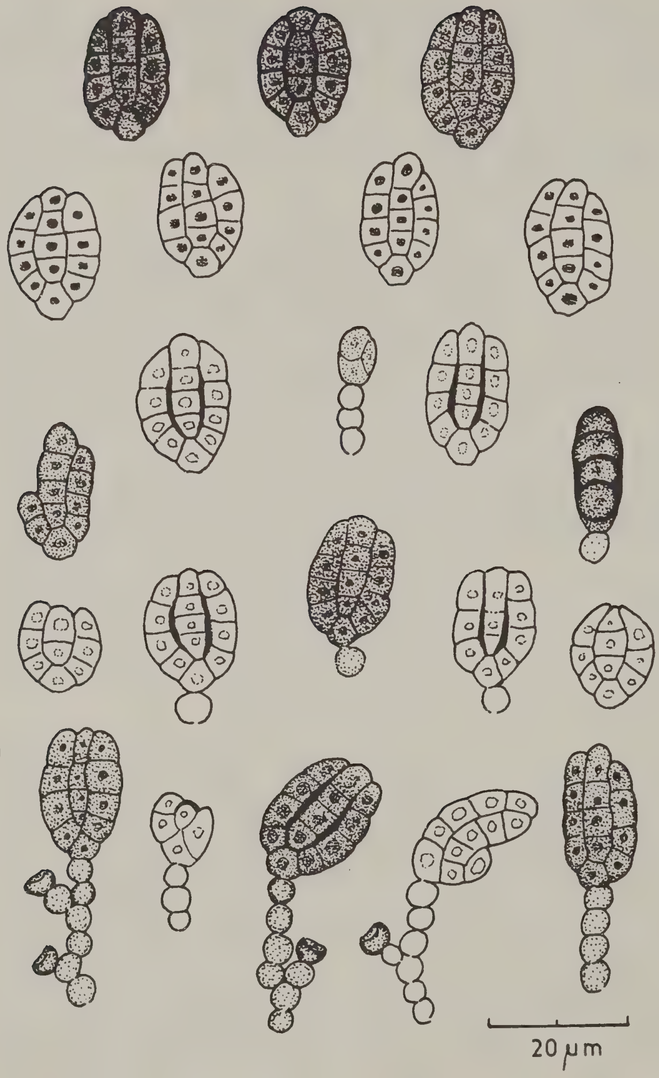

Fig. 6. *Cheiropolyschema ghaticum* anam.-sp. nov.: torulose conidiophores, and cheirosporous conidia.

Cheirosporous conidia are known in a number of genera, including *Cheiromoniliophora* Tzean & Chen (1990), *Cheiropolyschema* Matsushima (1971), *Dictyosporium* Corda (Bhat and Sutton, 1985b; Ellis, 1971, 1976; Matsushima, 1975) and *Pseudodictyosporium* Matsushima (1975). Conidiogenesis and morphology of conidiogenous cells were important in the delimitation of these genera. Only in *Cheiropolyschema* are the conidia developed on catenulate, spherical conidiogenous cells. *Cheiropolyschema ghaticum* resembles the type species, *C. formosana*, but its conidiogenous cells often become cupulate after conidium secession, a feature also seen in genera such as *Torula* Persoon ex Fries and *Dwayabeeja* Subramanian (Ellis, 1971). Further, the conidiogenous cells often secede with the conidia, as they do in *Dictyosporium gauntii* Bhat & Sutton (1985b).

***Craspedodidymum fimbriatum*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 7)
(Etym. Latin: *fimbriatus* = fringed)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae gregariae, effusae, atrobrunneae, velutinae. Conidiophora mononematica, 4-20 aggregata, erecta, recta, crassitunicata, atrobrunnea, non-ramosa, 150-240 µm alt., 6-7.5 µm lat., 5-8-septata, e stromatibus parvibus ca. 50 µm lat. exorientia. Cellulae conidiogenae terminales, integratae, monophialidicae, clavatae vel cylindrico-clavatae, ad apicem leniter inflatae et rotundatae, brunneae vel atrobrunneae, 25-32 µm long., 5.5-7.5 µm lat. ad basim, 11-13.5 µm lat. supra, apicem versus angustatae, collarulo inconspicuo, expanso, 7.5 µm lat., praeditae. Conidia blastico-phialidica, globosa, non-septata, crassitunicata, brunnea, 18-24 µm diam., cum appendicibus numerosis fibrillosis, curvatis, chlamydem 2-3 µm cr. formantibus; ad apicem conidiophori in massis mucosis incoloratis aggregata, vel post secessionem nonnunquam lateribus cellularum conidiogenarum adhaerentia.

Conidial fungi, hyphomycetes. Colonies gregarious, effuse, dark brown, velvety. Conidiophores mononematous, fasciculate in groups of 4-20, erect, straight, thick-walled, dark brown, unbranched, 150-240 µm tall, 6-7.5 µm wide, 5-8-septate, septa 20-28 µm apart, developing from small stromata about 50 µm wide. Conidiogenous cells terminal, integrated, monophialidic, clavate to cylindric-clavate, slightly inflated and rounded at the apex, medium to dark brown, 25-32 µm long, 5.5-7.5 µm wide at the base, 11-13.5 µm wide above, narrowing toward the apex, which bears an inconspicuous, flared collarette 7.5 µm wide. Conidia blastic-phialidic, globose, non-septate, thick-walled, medium brown, 18-24 µm diam., with

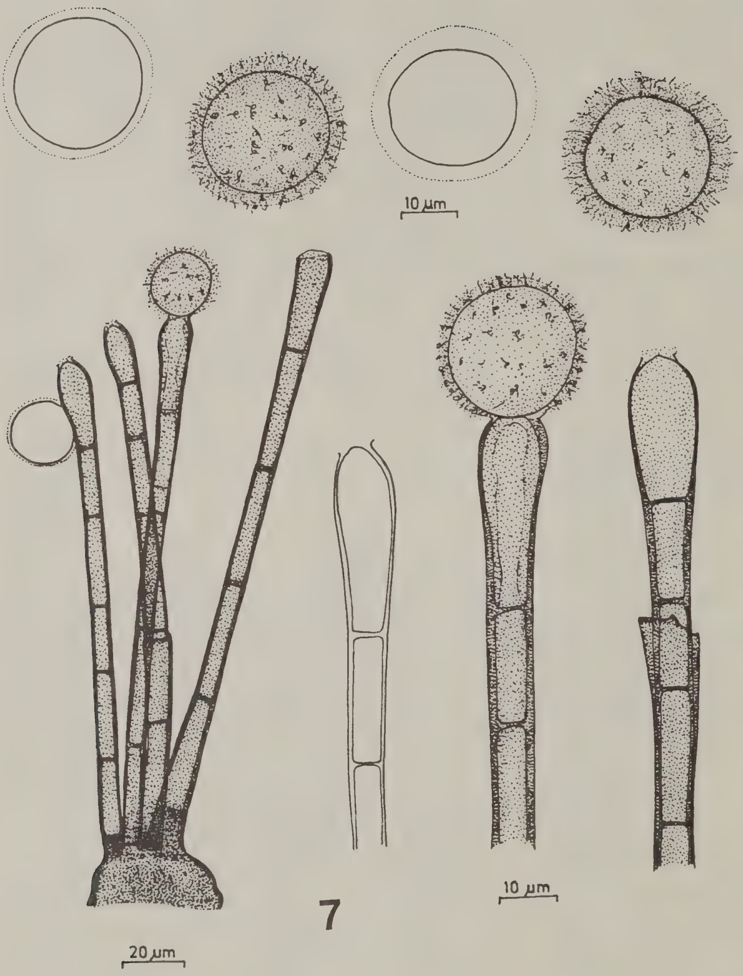
10 µm
10 µm
20 µm
7

Fig. 7. *Craspedodidymum fimbriatum* anam.-sp. nov.: stroma, conidiophores and fimbriate conidia.

numerous acellular, fibrillose, curved appendages forming a pile or coat 2-3 μm thick on the surface; accumulating in colourless slimy masses at the apex of the conidiophore, or sometimes adhering to the sides of conidiogenous cells after secession.
HOLOTYPE: on decaying twigs, Shiradi Ghat, Karnataka State, India, 18 Dec. 1988, D.J. Bhat, Herb. DAOM 214598.
Teleomorph: unknown.

***Craspedodidymum hyalosporum*** Bhat & Kendrick **anam.-sp. nov.**
(Etym. Greek: *hyaleos* = glassy, transparent) (Fig. 8)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, pilosae, atrobrunneae vel nigrae. Conidiophora mononematica, ex stromatibus atrobrunneis, 25-45 μm lat., oriunda; erecta, recta vel leniter flexuosa, laevia, crassitunicata, atrobrunnea, non-ramosa, saepe percurrenter renascentia, 180-290 μm alt., ad basim 9-11.5 μm lat., apicem versus attenuata ad 5-7.5 μm lat., 8-12-septata. Cellulae conidiogenae terminales, integratae, monophialidicae, clavatae vel cylindrico-clavatae, 25-38 μm long., 5-6.5 μm lat. ad basim, 8-10 μm lat. in parte superiore, pallide brunneae vel brunneae, collarulo prominenti, tenuitunicati, cupulato et expanso, usque ad 6.5 μm profundo, usque ad 8 μm lat., basi constricto, 4-5 μm lat., praeditae. Conidia blastico-phialidica, brevi-cylindrica vel late ellipsoidea, utrinque rotundata, laevia, incolorata, 1-septata, interdum leniter constricta ad septum, 8-12.5 X 4-6 μm, ad apicem conidiophori in massis mucosis incoloratis aggregata.

Conidial fungi, hyphomycetes. Colonies effuse, hairy, dark brown to black. Conidiophores mononematous, arising from dark brown stromata 25-45 μm wide, erect, straight or slightly flexuous, smooth, thick-walled, dark brown, unbranched, often percurrently regenerating at cut ends, 180-290 μm tall, 9-11.5 μm wide at the base, tapering to 5-7.5 μm wide above, 8-12-septate, septa 15-25 μm apart. Conidiogenous cells terminal, integrated, monophialidic, clavate to cylindrical-clavate, 25-38 μm long, 5-6.5 μm wide at the base, 8-10 μm wide in the upper half, pale to medium brown, with a prominent, thin-walled, cup-shaped and flared collarette, up to 6.5 μm deep, up to 8 μm wide at the flared open end, distinctly constricted at the base, which is 4-5 μm wide. Conidia blastic-phialidic, short-cylindrical to broadly ellipsoidal, rounded at both ends, smooth, colourless, 1-septate, sometimes slightly constricted at the septum, 8-12.5 X 4-6 μm, accumulating in colourless slimy masses at the conidiophore apex.
HOLOTYPE: on decaying twigs, Edakumeri, Dakshina Kannada District,

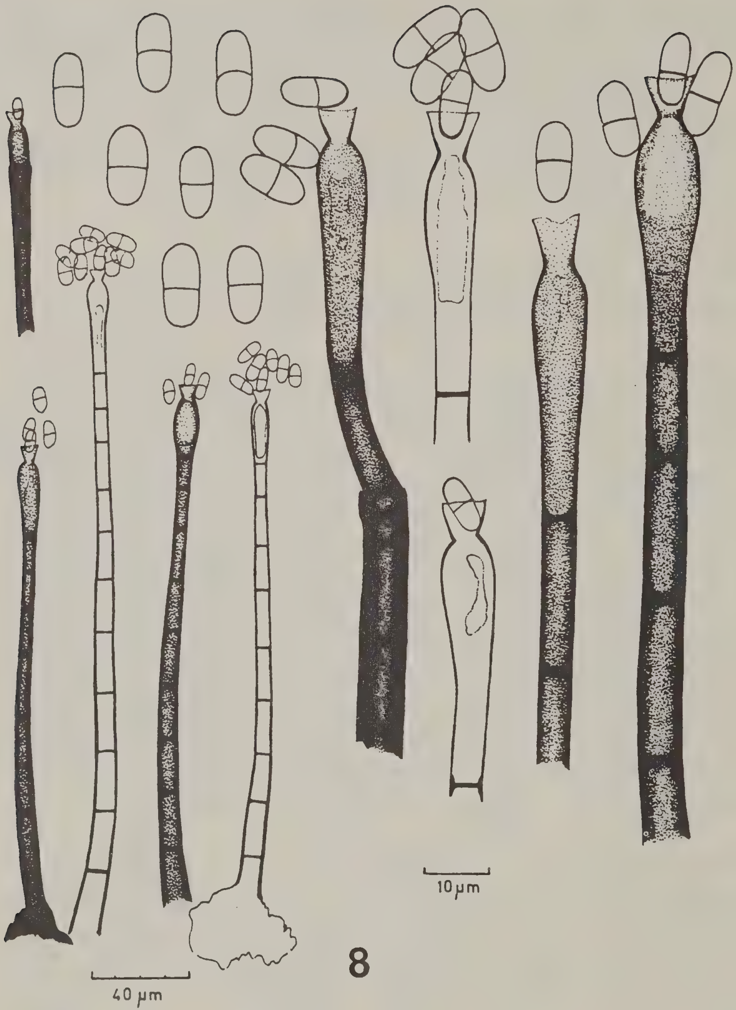

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Fig. 8. *Craspedodidymum hyalosporum* anam.-sp. nov.: conidiophores, apical phialides with collarettes, and didymosporous conidia.

Karnataka State, India, 5 Oct. 1989, D.J. Bhat, DAOM 214599.
Teleomorph: unknown.

The genus *Craspedodidymum* Holubová-Jechová (1972) is typified by *C. elatum* Holubová-Jechová, which has branched conidiophores terminating in apically inflated phialides with large funnel-shaped collarettes, producing brown, non-septate conidia in slimy heads. Three further species have been described in this genus: *C. abigianense* Lunghini & Onofri (1980), *C. proliferans* Rao & de Hoog (1986), and *C. pulneyensis* Subramanian & Bhat (1987). *Craspedodidymum abigianense* produces lateral as well as terminal collarettes (the conidiogenous cells therefore being polyphialides), and the conidiophores are unbranched. The conidiophores of *C. proliferans* are unbranched, but percurrently proliferating. In *C. fimbriatum*, the collarette is inconspicuous and the slimy, globose, nonseptate conidia have a densely fibrillose surface. In *C. hyalosporum* the conidia are colourless and 1-septate.

We have determined that *C. pulneyensis* Subramanian & Bhat is almost identical with *C. proliferans*, so it may now be regarded as a facultative synonym of *C. proliferans*.

*Craspedodidymum proliferans* Rao & de Hoog,
Stud. Mycol. **26**:64-65 (1986).
= *Craspedodidymum pulneyensis* Subramanian & Bhat,
Kavaka **15**:52-54 (1987).

Kirk (1985) described *Dischloridium keniense* P.M. Kirk with unbranched, percurrently proliferating conidiophores terminating in distinct cup-shaped phialidic collarettes and ellipsoidal to obovoid, 1-septate, darkly pigmented conidia. At the time he recognized the similarity of his new taxon to *Craspedodidymum*, but thought it generically distinct from *C. elatum*. The subsequent apparently reasonable expansions of the generic concept of *Craspedodidymum* now make it appropriate to transfer *D. keniense* to this genus.

***Craspedodidymum keniense*** (P.M. Kirk) Bhat & Kendrick
**comb. nov.**
≡ *Dischloridium keniense* P.M. Kirk, Mycotaxon **23**:320-322
(1985).

***Cryptophiale apicalis*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 9)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, hirsutae, inconspicuae. Mycelium immersum, sparsum, ex hyphis ramosis, septatis, brunneis, ca. 4 µm lat., compositum. Conidiophora mononematica, proprie characteristica; axis principalis setiformis, rectus sed versus apicem modice curvatus, atro-brunneus, laevis, crassitunicatus, usque ad 300 µm long., basi usque ad 40 µm lat., in medio 10-15 µm lat., ad apicem acutus; usque ad 16-septatis, septis infra zonam fertilem 30-38 µm distantibus, in zona fertili 8-14 µm distantibus, apice ultra zonam fertilem 12-25 µm protrudenti. Zona fertilis argute propria, subapicalis et unilateralis, secus curvamen interiorem conidiophororum exoriens, 40-75 µm long., ex tribus monatibus composita: (1) 5-8 axis principalis rami, breves, laterales, axis principalis ad intervalla plus minusve regularia circum peripheriam orientes; hi rami basi leniter constricti, brunnei vel atro-brunnei, modice incurvi, subulati, laeves, 1-2-septati, 30-45 µm long., prope basim 4-7 µm lat.; (2) cellulae steriles plus minusve cylindricae, pallide brunneae, 18-24 X 3-4.5 µm; (3) cellulae conidiogenae monophialidicae, discretae, cylindricae, cum apertura angusta fertili, vallum arcte contiguum formantes, sed plerumque cellulis sterilibus absconditae. Conidia falcata, non-septata, laevia, incolorata, 9-14 X 1.5-2 µm, in massis mucosis incoloratis aggregata.

Conidial fungi, hyphomycetes. Colonies effuse, hairy, inconspicuous. Mycelium immersed, sparse, composed of branched, septate, brown hyphae, about 4 µm wide. Conidiophores mononematous, differentiated; main axis setiform, erect but gently curved near the apex, dark brown, smooth, thick-walled, up to 300 µm long, up to 40µm wide at the base, 10-15 µm wide in the middle, tapering to a pointed tip; up to 16-septate, septa 30-38 µm apart below the discrete fertile zone, 8-14 µm apart in the fertile zone, apex protruding 12-25 µm beyond the fertile zone. Fertile zone sharply delimited, subapical and unilateral, arising along the inner curve of the conidiophore, 40-75 µm long, composed of three elements: (1) a series of 5-8 short, lateral branches of the main axis arising at more or less regular intervals around the periphery; these branches slightly constricted at the base, brown to dark brown, gently incurved, subulate, smooth, 1-2-septate, 30-45 µm long, 4-7 µm wide near the base; (2) more or less cylindrical, pale brown, sterile cells 18-24 X 3-4.5 µm; (3) conidiogenous cells that are monophialidic, discrete, cylindrical, with a narrow fertile aperture, and in a tightly packed palisade, but generally obscured by the sterile cells. Conidia falcate (curved and pointed at both ends), non-septate (amerosporous), smooth-walled, colourless, 9-14 X 1.5-

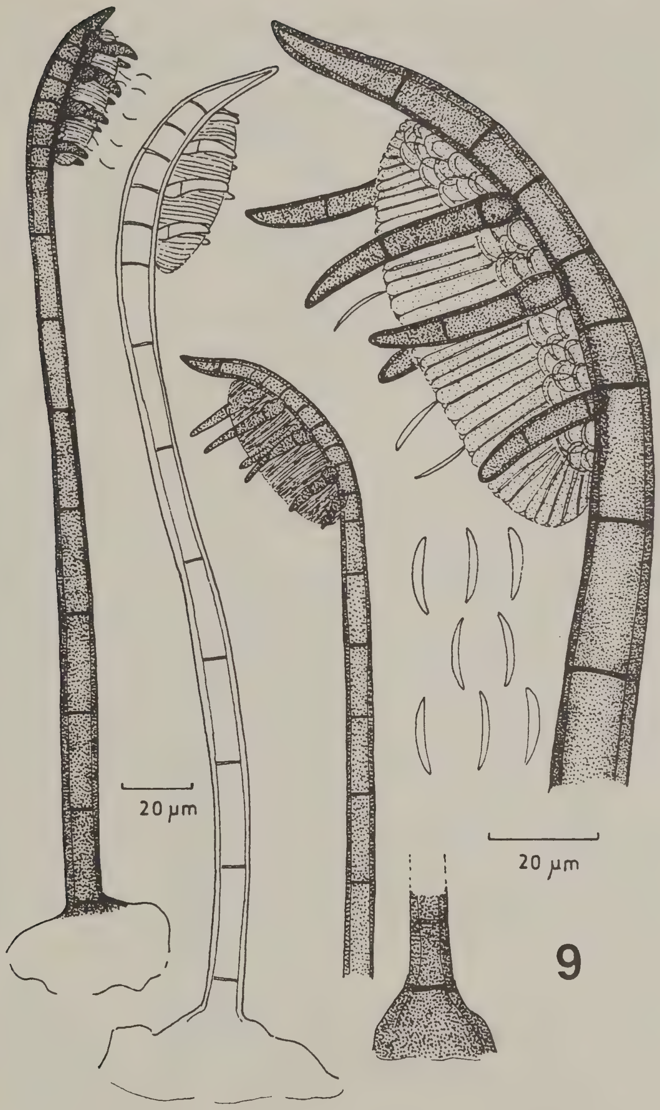


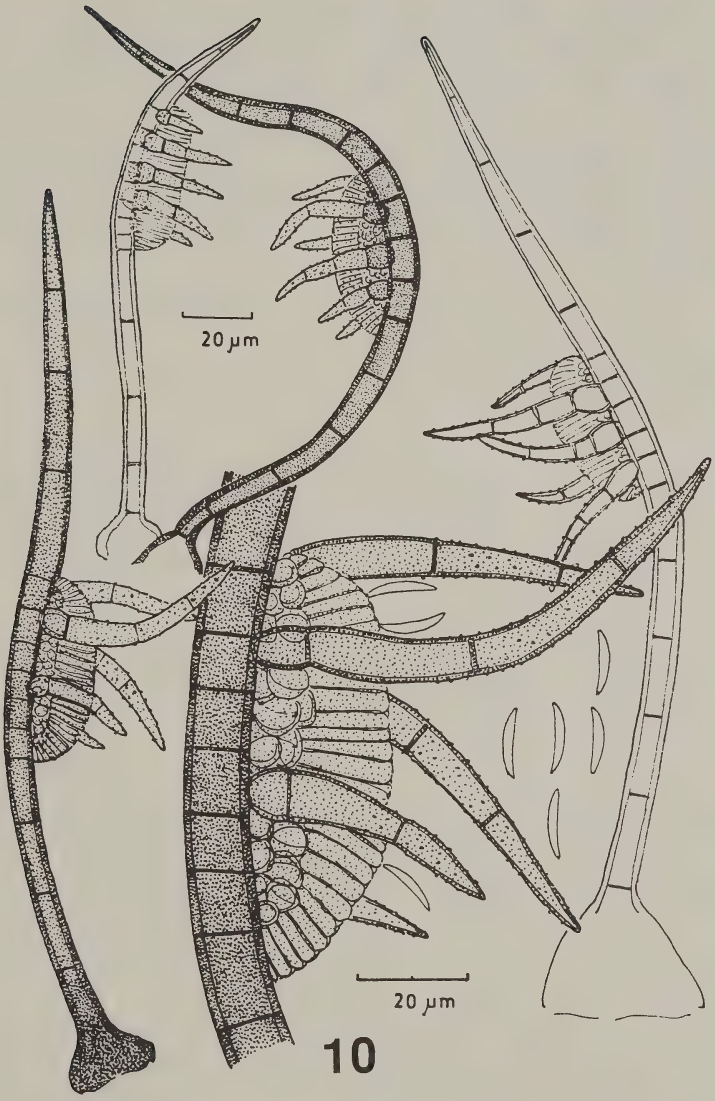
Fig. 9. *Cryptophiale apicalis* anam.-sp. nov.: setose conidiophores with sub-apical, unilateral fertile zone, and falcate, amerosporous conidia.

2 μm, accumulating in colourless mucus.
HOLOTYPE: on dead leaves of *Vateria indica* L. (Dipterocarpaceae), Shiradi Ghat, Dakshina Kannada District, Karnataka State, India, D.J. Bhat, 16 Aug. 1989. DAOM 214248.
Teleomorph: unknown.

***Cryptophiale verrucosa*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 10)
(Etym. Latin: *verrucosus* = warty)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, hirsutae, inconspicuae. Mycelium immersum, ex hyphis ramosis, septatis, brunneis, ca. 4.5 μm lat., compositum. Conidiophora mononematica, proprie characteristica; axis principalis setiformis, rectus sed versus apicem modice curvatus, atro-brunneus, laevis, crassitunicatus, usque ad 260 μm long., basi 20-32 μm lat., in medio 10-12 μm lat., ad apicem acutus; usque ad 16-septata, septis infra et supra zonam fertilem 25-32 μm distantibus, in zona fertili 8-15 μm distantibus, apice ultra zonam fertilem 50-90 μm protrudenti. Zona fertilis argute propria, medialis et unilateralis, secus curvamen interiorem conidiophororum exoriens, 50-80 μm long., ex tribus monatibus composita: (1) 4-8 axis principalis rami, breves, laterales, axis principalis ad intervalla plus minusve regularia circum peripheriam orientes; hi rami basi leniter constricti, pallide brunnei vel brunnei, modice incurvi, subulati, conspicue verrucosi, 2-3-septati, 45-90 μm long., 5-9 μm lat. prope basim; (2) cellulae steriles plus minusve cylindricae, pallide brunneae, 18-25 X 2.5-4.5 μm; (3) cellulae conidiogenae monophialidicae, discretae, cylindricae, cum apertura angusta, vallum arcte contiguum formantes, sed plerumque cellulis sterilibus absconditae. Conidia falcata, non-septata, laevia, incolorata, 9-12 X 1.5-2 μm, in massis mucosis incoloratis nata.

Conidial fungi, hyphomycetes. Colonies effuse, hairy, inconspicuous. Mycelium immersed, composed of branched, septate, brown hyphae about 4.5 μm wide. Conidiophores mononematous, highly differentiated, main axis erect but slightly to distinctly curved in the middle, brown to dark brown, smooth, thick-walled, up to 260 μm long, 20-32 μm wide at the bulbous base, 10-12 μm wide in the middle, tapering to a pointed tip; up to 16-septate, with septa 25-32 μm apart in the apical and basal sterile regions, 8-15 μm apart in the median fertile zone, apex protruding 50-90 μm above the fertile zone. Fertile zone sharply delimited, median and unilateral, arising along the inner curve of the conidiophore, 50-80 μm long, composed of three elements: (1) a series of 4-8 short lateral branches of the main axis arising at more or less regular intervals around



**10**

Fig. 10. *Cryptophiale verrucosa* anam.-sp. nov.: setose conidiophores, median, unilateral fertile zone, verrucose branches, and falcate conidia.

the periphery, these branches pale brown to brown, slightly constricted at the base, slightly to distinctly curved, subulate, distinctly warty, 2-3-septate, 45-90 µm long, 5-9 µm wide near the base; (2) a palisade of sterile, flat, cylindrical, pale brown cells, 18-25 X 2.5-4 µm; (3) conidiogenous cells that are monophialidic, discrete, cylindrical, with a narrow fertile aperture, in a tightly packed palisade, but generally obscured by the sterile tissue. Conidia falcate, non-septate, smooth-walled, colourless, 9-12 X 1.5-2 µm, accumulating in colourless slimy masses.
HOLOTYPE: on dead leaves of *Vateria indica* L. (Dipterocarpaceae), Sampaje Ghat, Kodagu District, Karnataka State, India, D.J. Bhat, 23 Nov. 1989, DAOM 214249.
Teleomorph: unknown.

Pirozynski (1968) introduced the generic name *Cryptophiale* for two distinctive fungi, which were described as *C. kakombensis* Pirozynski (the type species) on dead leaves of *Baphia* sp. from Tanzania, and *C. udagawae* Pirozynski & Ichinoe on dead leaves of *Quercus* sp. from Japan. The genus was characterized as having tall, dark, setose, apically branched conidiophores with a discrete lateral fertile zone consisting of a patch of pigmented sterile tissue bearing a tightly packed palisade layer of pigmented phialides, each giving rise to a succession of colourless, lunate or falcate, slimy conidia. Kirk & Sutton (1985), in a reassessment of the anamorph genus *Chaetopsina* Rambelli and closely related taxa, limited *Cryptophiale* to anamorphic fungi with sessile conidiogenous cells borne unilaterally and in a submedian position on setiform, apically unbranched or branched conidiophores, and obscured by a palisade of shield-shaped sterile cells. If this generic concept is accepted, nine described species fit the genus: *C. kakombensis* Pirozynski and *C. udagawae* Pirozynski & Ichinoe (Pirozynski, 1968), *C. guadalcanalensis* Matsushima (1971), *C. iriomoteana* Matsushima (1975), *C. manifesta* Sutton & Hodges (1976), *C. minor* Farr (1980), *C. aristata* Kuthubutheen & Sutton (1985), *C. cucullata* Kuthubutheen (1987) and *C. enormis* Sutton, Nawawi & Kuthubutheen (1989). Using characters derived from the morphology of the conidiophores, fertile zones and conidia, Sutton *et al.* (1989) published a dichotomous key to the known species of *Cryptophiale*.

Although *C. apicalis* and *C. verrucosa* have similar conidia and conidiogenous cells, the fertile zone in *C. apicalis* is subapical, while that in *C. verrucosa* is median on the conidiophore. The lateral branches of *C. apicalis* are smooth-walled, 30-45 µm long and dark brown, whereas in *C. verrucosa* they are distinctly verrucose, 45-90 µm long and mid-brown. Several collections have been made of both of our new species: these specimens confirm the stable nature of the interspecific differences.

Both new species can be readily distinguished from the other nine species of *Cryptophiale*. Our species have conidiophores that branch subterminally, and exclusively on one side. In six of the other nine species the conidiophore axes are unbranched; in the remaining three (*C. udagawae*, *C. guadalcanalensis* and *C. cucullata*) the conidiophores branch apically and dichotomously.

*Chaetopsina ramifera* Matsushima (1971) and *C. splendida* Sutton & Hodges (1976) resemble *Cryptophiale verrucosa* and *C. apicalis* in having 5-7 branches of the conidiophore axis arising in association with the fertile zone. However, in the *Chaetopsina* species the branches are not spaced around the periphery of the zone, but are grouped above that zone. In the *Chaetopsina* species the fertile zone is not palisade-like, and it lacks the shield-like sterile cells so evident in species of *Cryptophiale*.

Rambelli and Onofri (1987) emended the generic diagnosis of *Xenokylindria* Di Cosmo *et al*. (1983) to accommodate mononematous hyphomycetous anamorphs with percurrently proliferating conidiogenous cells. They proceeded to describe *X. ciliata* Onofri & Rambelli, which had non-septate, bisetulate conidia that they believed arose from percurrently proliferating conidiogenous cells. Unfortunately, although their line-drawings showed annellations at the narrow tip of the conidiogenous cells, their photomicrographs did not provide any confirmation of this. In principle, percurrent proliferations should result in increase in length of the conidiogenous cells, but the illustrations given by Onofri and Rambelli do not show this. It is also usual for setulate conidia to be produced from phialides. We have collected a fungus from the Western Ghats which is clearly identical with the one they found in the Ivory Coast. We have examined the fungus for any sign of percurrent proliferation and the resultant annellations, but failed to find any: the collarettes are all of the same length, and show no sign of annular scars. It would therefore appear that this fungus would be best disposed in *Dictyochaeta* Spegazzini, and we make the requisite combination.

***Dictyochaeta ciliata*** (Onofri & Rambelli) Bhat & Kendrick **comb. nov.** (Fig. 11)

= *Xenokylindria ciliata* Onofri & Rambelli, Trans. Brit. mycol. Soc. **88**: 397. 1987.

**11**

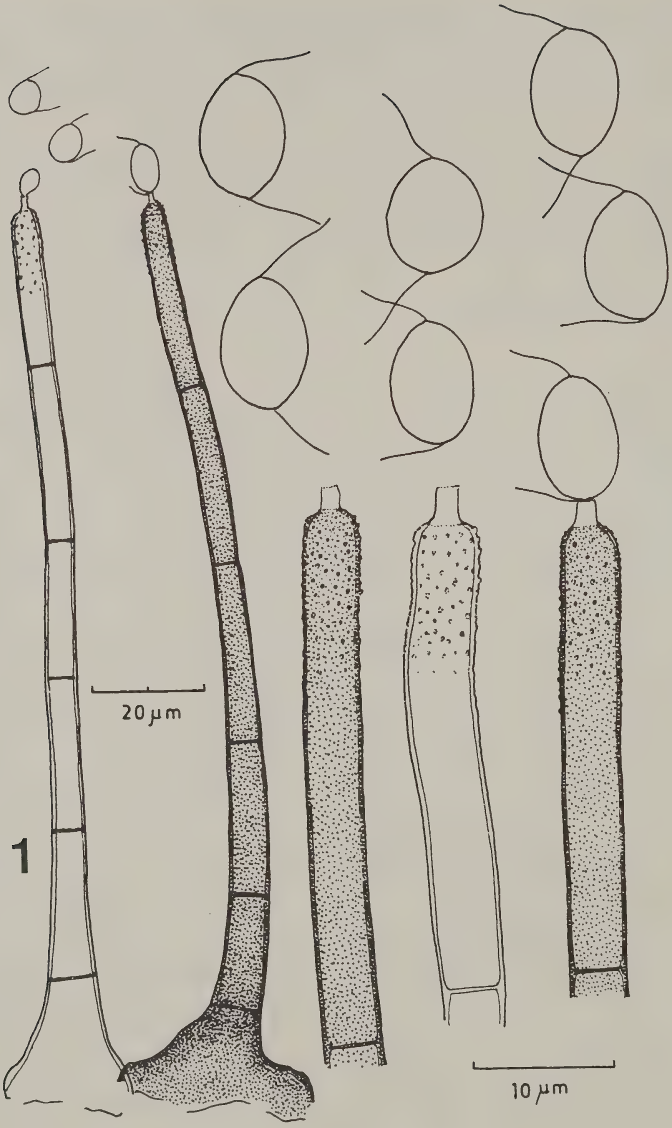


Fig. 11. *Dictyochaeta ciliata* comb. nov.: conidiophores and bisetulate, amerosporous conidia.

Conidial fungi, hyphomycetes. Colonies effuse, pale brown to brown, hairy. Mycelium mostly immersed, partly superficial, composed of branched, septate, pale brown to brown hyphae 2.5-4 µm wide. Setae absent. Conidiophores differentiated, erect, straight or slightly curved, smooth, thick-walled, up to 6-septate, unbranched, dark brown to black at the base, brown at the apex, up to 160 µm tall, 15-20 µm wide at the base, 5-8.5 µm wide above. Conidiogenous cells blastic-phialidic, terminal, integrated, determinate, upper half distinctly verrucose, smooth below, with a narrow, cylindrical, colourless collarette, 2-3 µm deep, 1-2 µm wide. Conidia slimy, ellipsoidal, smooth, colourless, non-septate, 6.5-10.5 X 6-8 µm, with a single setula, 5-8 µm long, at each end; lower setula arising at right angles to the conidium axis. Conidia accumulating in colourless slimy droplets.

Specimen examined: on dead leaves of *Cinnamomum* sp. (Lauraceae), Kudremukh, Karnataka State, India, D.J.Bhat, 2 July 1989, DAOM 214600.

Teleomorph: unknown.

***Dictyochaeta tropicalis*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 12)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, pilosae, griseo-brunneae, velutinae. Conidiophora mononematica, erecta, recta vel flexuosa, non-ramosa, laevia, 5-6-septata, infra atrobrunnea, superne pallide brunnea, 90-130 µm alt., basim versus exigue vel conspicue inflatam ad 17 µm lat., ad apicem 4.5-6 µm lat. Cellulae conidiogenae terminales, integratae, monophialidicae, cylindricae, supra leniter latiores, 15-25 µm long, 6-7.5 µm lat., cum collarulo apicali 2-2.5 µm alt. et 3 µm lat., conidia iterum atque iterum in loco eodem producentes. Conidia blastica-phialidica, non-septata, ellipsoidea vel guttuliformia, versus apicem attenuata, basi truncata vel obtusa, 7.5-9.5 X 3-5 µm, incolorata, laevia, utrinque una setula praedita; setula apicalis arrecta, 2.5-3 µm long., velut extensio apicis conidii attenuati oriunda; setula basalis curvata, usque ad 3.5 µm long., excentrica; ad apicem cellularum conidiogenarum in massis mucosis incoloratis aggregata.

Conidial fungi, hyphomycetes. Colonies effuse, hairy, greyish brown, velvety. Conidiophores mononematous, erect, straight or flexuous, unbranched, smooth, 5-6-septate, dark brown below and pale brown above, 90-130 µm tall, up to 17 µm wide at the slightly to conspicuously swollen base, 4.5-6 µm wide above. Conidiogenous cells terminal, single, integrated, monophialidic, cylindrical, slightly wider above, 15.5-25 X 6-7.5 µm, with a flared apical collarette 3 µm wide and 2-2.5 µm deep,

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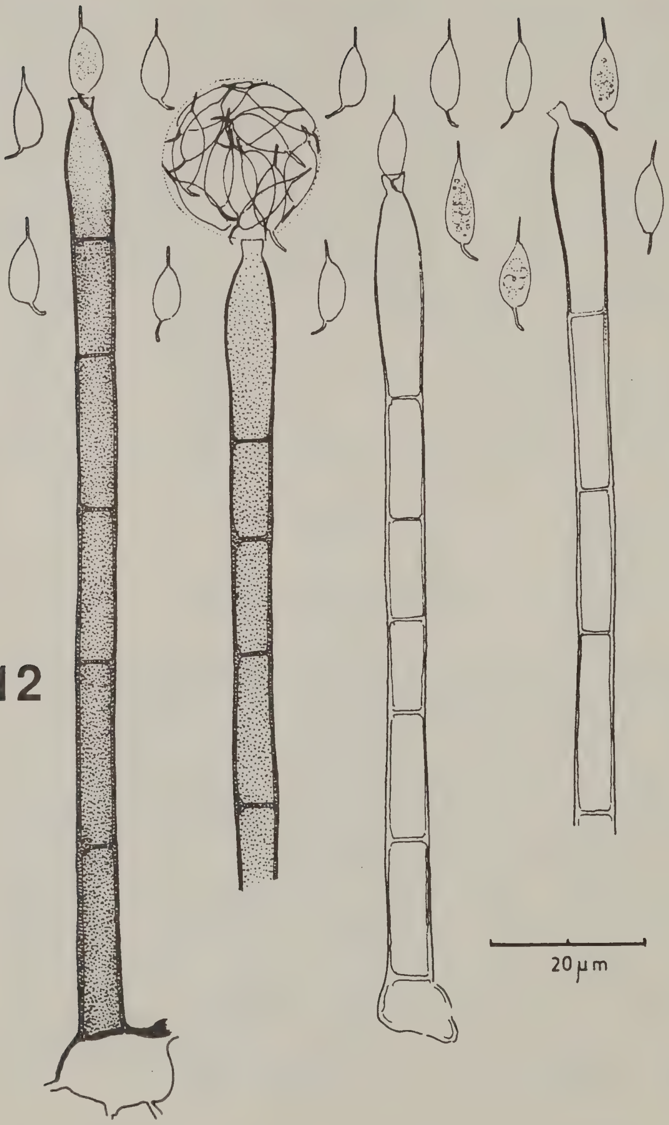

Fig. 12. *Dictyochaeta tropicalis* anam.-sp. nov.:
conidiophores, apical phialides,
and bisetulate, amerosporous conidia.

producing a basipetal succession of conidia without any extension growth of the conidiogenous cell. Conidia blastic-phialidic, non-septate, ellipsoid to drop-shaped, tapering to a pointed apex, truncate to obtuse at the base, 7.5-9.5 X 3-5 µm, colourless, smooth, with a setula at each end: apical setula straight, 2.5-3 µm long and arising as an extension of the tapering conidium apex; basal setula curved, up to 3.5 µm long and arising from one side of the broadly truncate base, accumulating in a slimy droplet at the apex of the phialide.
HOLOTYPE: on dead leaves, Mt. Harriet, South Andaman Island, India, 4 May 1990, D.J. Bhat, DAOM 214601.
Teleomorph: unknown.

*Dictyochaeta tropicalis* is unique in its ellipsoidal to drop-shaped, colourless, bisetulate conidia produced on monophialidic conidiophores bearing distinct collarettes. The apical setula is always straight, the basal setula curved. Kuthubutheen and Nawawi (1991b) have recently provided a key to 69 species so far described in *Dictyochaeta* Spegazzini and *Codinaea* Maire (Hughes and Kendrick, 1968; Gamundi *et al.*, 1977). Following Arambarri and Cabello (1989), Kuthubutheen and Nawawi regarded 59 species as appropriately disposed in *Dictyochaeta*. Arambarri and Cabello (1989) had maintained the remaining 10 species in *Codinaea* because these had branched conidiophores with distinct conidiogenous cells. The species these authors kept in *Codinaea* are indeed distinct from those placed in *Dictyochaeta*, but neither Arambarri and Cabello nor Kuthubutheen and Nawawi included among them the type species of *Codinaea*, *C. aristata*. It is illegitimate to exclude the type species from a genus while maintaining the original generic name for other species, and if the ten species are to be maintained as a distinct anamorph-genus, a new generic name must be provided for them.

In most species of *Dictyochaeta* the setulate conidia are falcate or lunate, and pointed at both ends. The conidiogenous cells are usually polyphialides (sympodially proliferating phialides with two to several conidiogenous apertures which function successively). *Dictyochaeta tropicalis* belongs in the second group delineated by Kuthubutheen and Nawawi, having non-septate, setulate conidia. It differs from other species in that group in several ways: (1) no polyphialides have been seen, (2) setae are absent, (3) the conidia are not falcate, (4) the conidia are smaller than those of otherwise similar species [*D. apiculata* Matsushima, *D. parva* Holubová-Jechová, *D. tilikfrei* Bhat & Sutton, and *D. vulgaris* (Hughes & Kendrick) Cabello & Arambarri (Arambarri and Cabello, 1989)].

***Dischloridium regenerans*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 13)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae, pilosae, velutinae. Conidiophora mononematica, erecta, recta vel flexuosa, usque ad 300 µm alt., 8-10 µm lat., 4-7-septata, septis 20-30 µm distantibus, non-ramosa, in dimidio inferiore vulgo verrucosa, crassitunicata, cylindrica, atrobrunnea, versus apicem pallescentiora, semel vel bis percurrenter extensa. Cellulae conidiogenae solitariae, integratae, terminales, monophialidicae, 70-100 X 8-10 µm, cylindricae, brunneae, apicis pariete periclinali leniter incrassato sine collarulo conspicuo. Conidia amerospora (non-septata), cylindrica vel ellipsoidea, apice obtusa, basi anguste truncata, crassitunicata, laevia, incolorata, 25-38 X 12-16 µm, ad apicem phialidis in massis mucosis incoloratis aggregata.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown, hairy, velvety. Conidiophores mononematous, differentiated, erect, straight or flexuous, up to 300 µm tall, 8-10 µm wide; 4-7-septate, septa 20-30 µm apart, unbranched, mostly verrucose in the lower half, thick-walled, cylindrical, dark brown, paler toward the apex, with 1-2 percurrent proliferations, up to 300 µm long, 8-10 µm wide. Conidiogenous cells integrated, terminal, monophialidic, 70-100 X 8-10 µm, cylindrical, medium brown, apical periclinal wall slightly thickened, but with no conspicuous collarette, 70-100 µm long, 8-10 µm wide. Conidia blastic-phialidic, cylindrical to ellipsoidal, obtuse at the apex, narrower and truncate at the base, non-septate, thick-walled, smooth, colourless, 25-38 X 12-16 µm, accumulating in colourless to whitish slimy masses.
HOLOTYPE: on dead twigs of a strangler fig (*Ficus* sp., Moraceae), Mt. Harriet, South Andaman Island, 4 May 1990, D.J. Bhat, DAOM 214603.
Teleomorph: unknown.

The generic name *Dischloridium* was introduced by Sutton (1977) for *Chloridium laeense* Matsushima (1971), originally described on leaves from Papua-New Guinea. Holubová-Jechová (1990) listed 7 species of *Dischloridium*, of which 4 have non-septate conidia. Of these, only *D. laeense* (Matsushima) Sutton (1977) and *D. roseum* (Petch) Seifert & Gams (1985) are close to *D. regenerans* in conidium shape and dimensions. The conidia of *D. regenerans* are almost as large as those of *D. roseum*, but shaped like the much smaller conidia of *D. laeense*. In addition, the lower half of the percurrently regenerating conidiophores of *D. regenerans* is often verrucose.

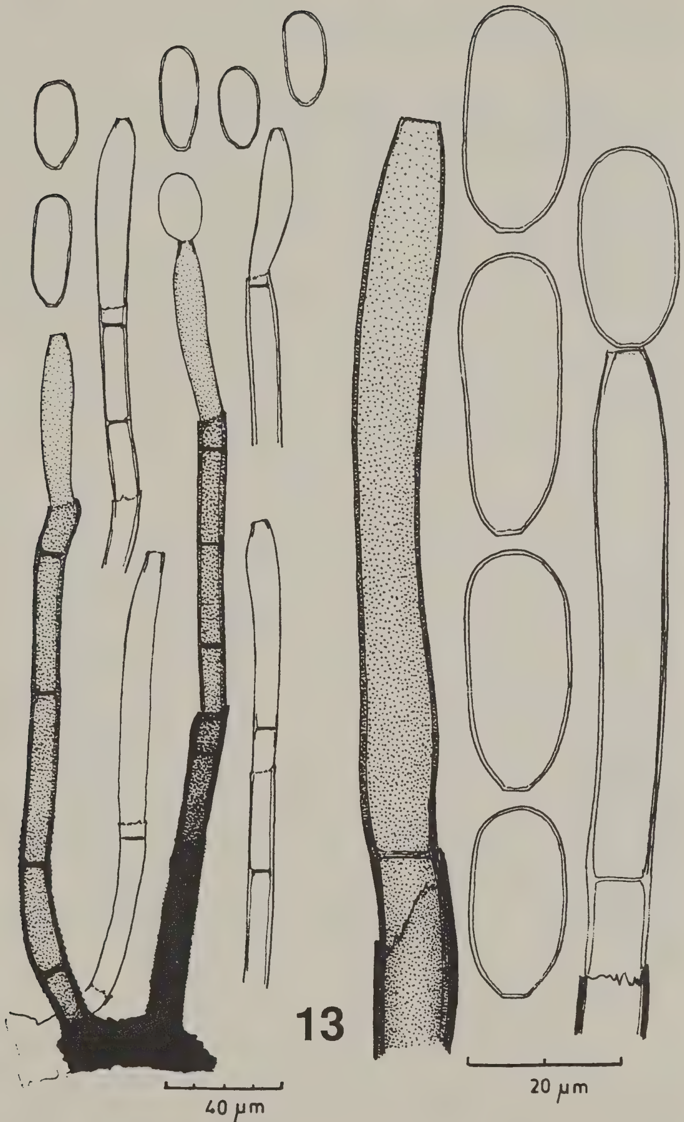
13
40 µm
20 µm

Fig. 13. *Dischloridium regenerans* anam.-sp. nov.: conidiophores and amerosporous conidia.

***Fusichalara goanensis*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 14)
(Etym. = pertaining to Goa State in India)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, brunneae, lanatae. Mycelium plerumque immersum, ex hyphis ramosis, septatis, 3.5-5 µm lat. compositum. Conidiophora mononematica, 2-4 in fasciculis enata, non-ramosa, arrecta, recta, brunnea vel aureo-brunnea, apicaliter pallescentiora, laevia, cylindrica vel subcylindrica, 3-4-septata, 80-110 µm long., 6-8.5 µm lat. Cellulae conidiogenae monophialidicae, cylindricae vel subcylindricae, 60-72 µm long., ventre parum inflato, 25-38 X 6.5-8.2 µm, et collarulo profundo 18-24 X 6.5-8 µm praeditae. Conidia mucosa, plus minusve cylindrica, apice rotundata, basi truncata, incolorata, laevia; conidiorum sunt 2 formae: conidia priora 3-septata, 17-22 X 5-6 µm; conidia cetera 1-septata, 12-15 X 4.5-5.5 µm, saepe in pseudo-catenis facile secedentibus nata.

Conidial fungi, hyphomycetes. Colonies effuse, brown, hairy. Mycelium mostly immersed, composed of branched, septate, hyphae 3.5-5 µm wide. Conidiophores macronematous, mononematous, arising in fascicles of 4-5, simple, erect, straight, brown to golden brown, apically paler, smooth, cylindrical to subcylindrical, 3-4-septate, 80-110 µm long, 6-8.5 µm wide. Conidiogenous cells monophialidic, cylindrical to subcylindrical, 60-72 µm long, with slightly inflated venter, 25-38 X 6.5-8.2 µm and a deep cylindrical collarette 18-24 X 6.5-8 µm, minutely flared only at the rim. Conidia slimy, nearly cylindrical, rounded at the apex, truncate at the base, colourless, smooth, of two kinds; first-formed conidia 3-septate, 17-22 X 5-6 µm; subsequent conidia 1-septate, 12-15 X 4.5-5.5 µm, often in readily seceding false chains.
HOLOTYPE: on decaying twigs, Cotigao Wildlife Sanctuary, Goa State, India, 14 July 1991, D.J. Bhat, DAOM 214604.
Teleomorph: unknown.

The genus *Fusichalara* was established by Hughes and Nag Raj (1973) for three *Chalara*-like anamorphic fungi: *F. dimorphospora* Hughes & Nag Raj (the type species), *F. dingleyae* Hughes & Nag Raj, and *F. novae-zelandiae* Hughes & Nag Raj. These differed from *Chalara* in the presence of a pronounced wall-thickening inside the phialide at the base of the collarette, and in producing two morphologically different kinds of conidia. Gams and Holubová-Jechová (1976) added another species, *F. minuta* Hol.-Jech., and a fifth, *F. clavatispora* P.M.Kirk apud Kirk and Spooner, was added in 1984. Our new species invites comparison only with *F. dingleyae* and *F. clavatispora*. *Fusichalara dingleyae* can be

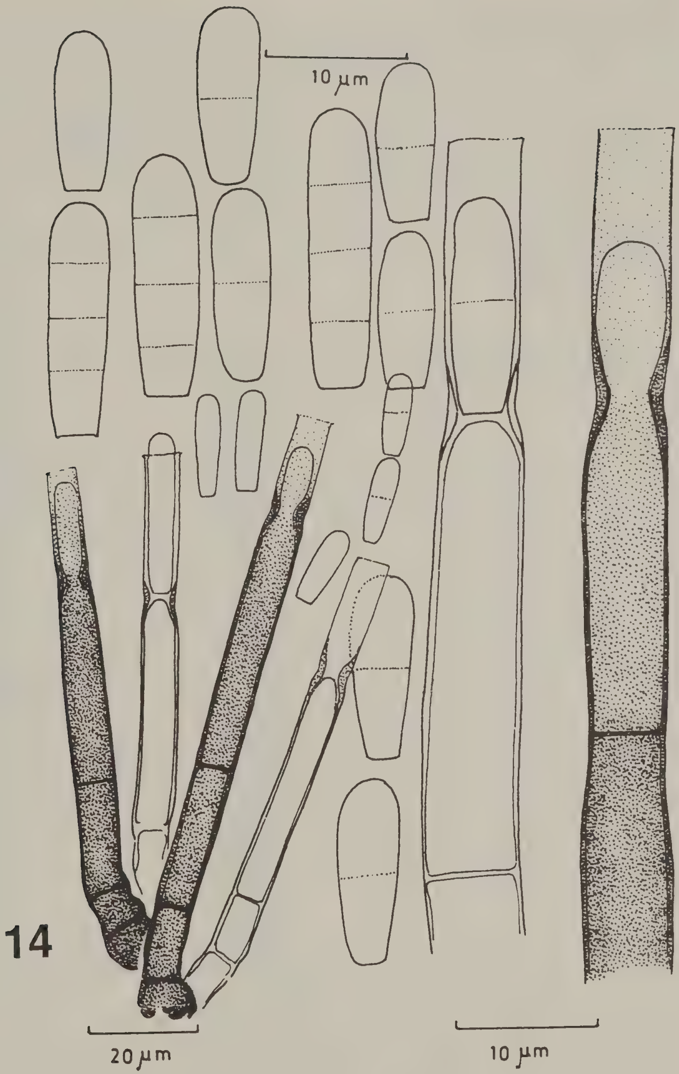
10 µm
14
20 µm
10 µm

Fig. 14. *Fusichalara goanensis* anam.-sp. nov.: conidiophores with integrated apical phialides and phragmosporous conidia.

differentiated from *F. goanensis* as follows: (1) its conidiophores are distinctly verrucose; (2) its primary conidia are much longer (up to 84 µm long and up to 7-septate); (3) its secondary conidia are fusiform. *F. clavatispora* can be distinguished from *F. goanensis* as follows: (1) the venter of its phialide is rather swollen and ellipsoidal; (2) there is no clear distinction between the first-formed and subsequent conidia, all are 1-3-septate and 12-16 X 3.5-4 µm: in *F. goanensis*, first-formed conidia are 3-septate and 17-22 X 5-6 µm; subsequent conidia are 1-septate, and 12-15 X 4.5-6.5 µm.

***Hyphopolynema stilboideum*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 15)
(Etym. Latin: *stilbius* = shining)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae, pilosae, velutinae, hypophyllae. Conidiomata synnematica, conspicua, erecta, atrobrunnea, 550-1250 µm alt., usque ad 110 µm lat. ad basim, usque ad 25 µm lat. in medio et supra, in caput fertile usque ad 45 µm lat. terminantia, ex conidiophoris adhaerentibus, parallelis, septatis, ramosis, brunneis, 3.5-4.5 µm lat., composita. Cellulae conidiogenae terminales, integratae, monophialidicae, cylindricae vel subcylindricae, parum latiores in medio quam utrinque, incoloratae usque subhyalinae, 30-40 X 3-4.5 µm, apertura phialidica 2.5 µm lat., collarulo inconspicuo, pariete periclinali incrassato praeditae. Conidia blastico-phialidica, fusiformia vel ellipsoidea, basi rotundata, apice leniter attenuata, 1-septata, ad septum leniter constricta, incolorata, laevia, 13-19 X 5-7 µm; una setula apicalis 8-10 µm long., et quattuor setulae similes, 8-15 µm long., aequidistantes circa basim; conidia in massis mucosis incoloratis aggregata.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown, hairy, velvety, hypophyllous. Conidiomata synnematal, determinate, conspicuous, erect, dark brown, 550-1250 µm tall, up to 110 µm wide at the base, up to 25 µm wide in the middle and above, terminating in a fertile head up to 45 µm wide, composed of tightly adherent, parallel, septate, branched, brown conidiophores, 3.5-4.5 µm wide. Conidiogenous cells terminal, clustered, integrated or discrete, monophialidic, cylindrical to subcylindrical, slightly wider in the middle than at either end, colourless to almost colourless, 30-40 X 3-4.5 µm, phialide aperture 2.5 µm wide, with an inconspicuous collarette, and some periclinal thickening. Conidia blastic-phialidic, fusiform to ellipsoid, base rounded, apex slightly tapered, 1-septate, very slightly constricted at the septum, colourless, smooth, 13-19 µm long, 5-7 µm wide, with 1 apical setula 8-

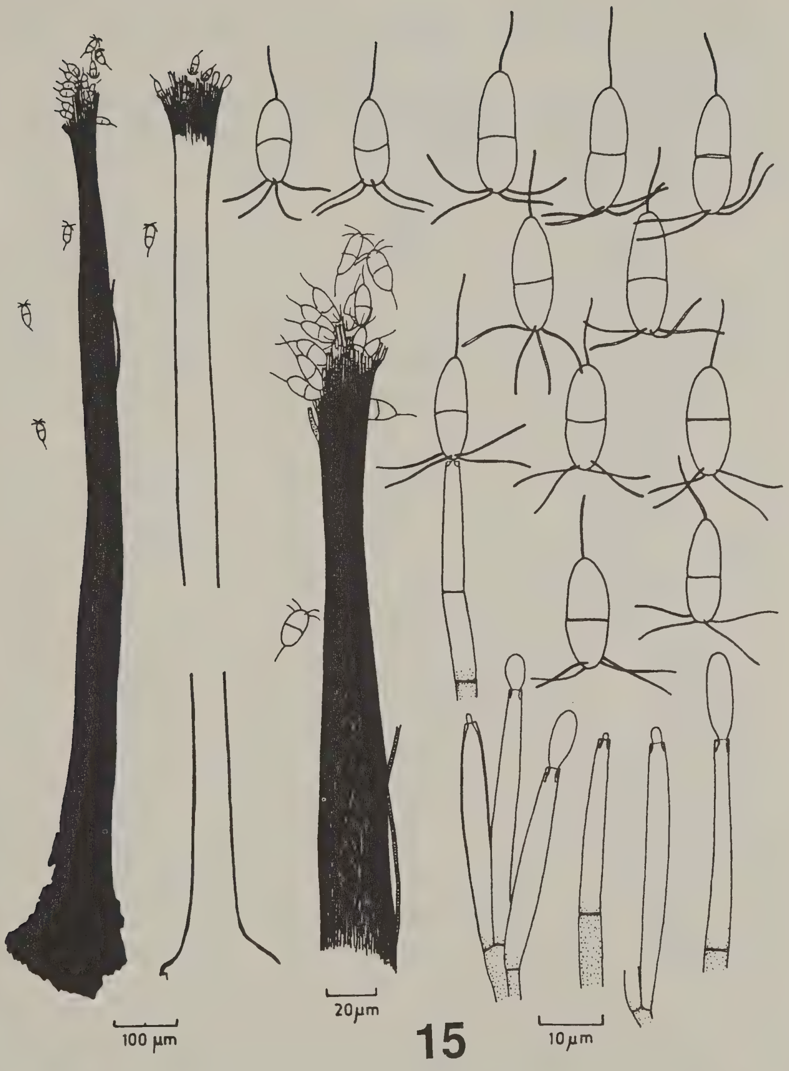
100 µm
20µm
15
10µm

Fig. 15. *Hyphopolynema stilboideum* anam.-sp. nov.: synnematal conidiomata, phialidic conidiogenous cells, and setulate, didymosporous conidia.

10 µm long, and with 4 similar setulae, 8-15 µm long, arising evenly spaced around the base; conidia accumulating in reflective, colourless slimy masses.
HOLOTYPE: on dead leaves of *Syzygium* sp. (Myrtaceae), Kodachadri Hills, Dakshina Kannada District, Karnataka State, India, 30 Dec. 1991, D.J. Bhat, DAOM 214605.
Teleomorph: unknown.

Several genera of synnematous hyphomycetes with setulate phialoconidia have been described (Ellis, 1971, 1976; Carmichael *et al.*, 1980; Mercado and Portales, 1985). The presence of setae in the synnemata, the shape of the conidia, and the number and position of the setulae have been given considerable importance in drawing generic distinctions. In *Thozetella nivea* Kuntze, the type species of *Thozetella*, the synnema has small, setoid structures called microawns, the colourless conidia are falcate and non-septate, and they have 1 setula at each end. In *Phialosporostilbe turbinata* Mercado & Portales, the type species of *Phialosporostilbe*, the colourless conidia are turbinate, and have 3 apical setulae and often 1 basal setula (see Fig. 17, of the similar *P. setosa*). In *Menisporopsis theobromae* Hughes, the type species of *Menisporopsis*, the synnema has a single large seta, the colourless conidia are falcate and non-septate, and they have 1 setula at each end. However, in *Menisporopsis pleiosetosa* Rao & de Hoog (1986), although the large seta characteristic of the genus is present, the colourless, non-septate conidia are obturbinate and have 1 apical and 2-4 basal setulae. This poses a taxonomic problem. In almost every character other than the large seta and the non-septate conidia, *M. pleiosetosa* resembles what we have named *Hyphopolynema stilboideum*. The other species of *Hyphopolynema* Nag Raj (Nag Raj, 1977; Sutton and Alcorn, 1984), are sporodochial, but in each case the characters of the conidiogenous cells and conidia are similar, each conidium bearing 1 apical and 2-4 basal setulae. It may become expedient to erect a new genus for *H. stilboideum* and *M. pleiosetosa* at some point, if other as yet undiscovered species form a group with them, and the difference between synnemata and sporodochia is perceived as a natural taxonomic hiatus.

***Kostermansinda andamanensis*** Bhat & Kendrick **anam.-sp. nov.**
(Etym. = pertaining to the Andaman Islands) (Fig. 16)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae, velutinae. Conidiomata synnematica, erecta, atrobrunnea, usque ad 420 µm alt., 40-70 µm lat. ad basim, 15-30 µm lat. in medio et supra, apice in capitulum fertile expanso et 90 µm lat., ex conidiophoris

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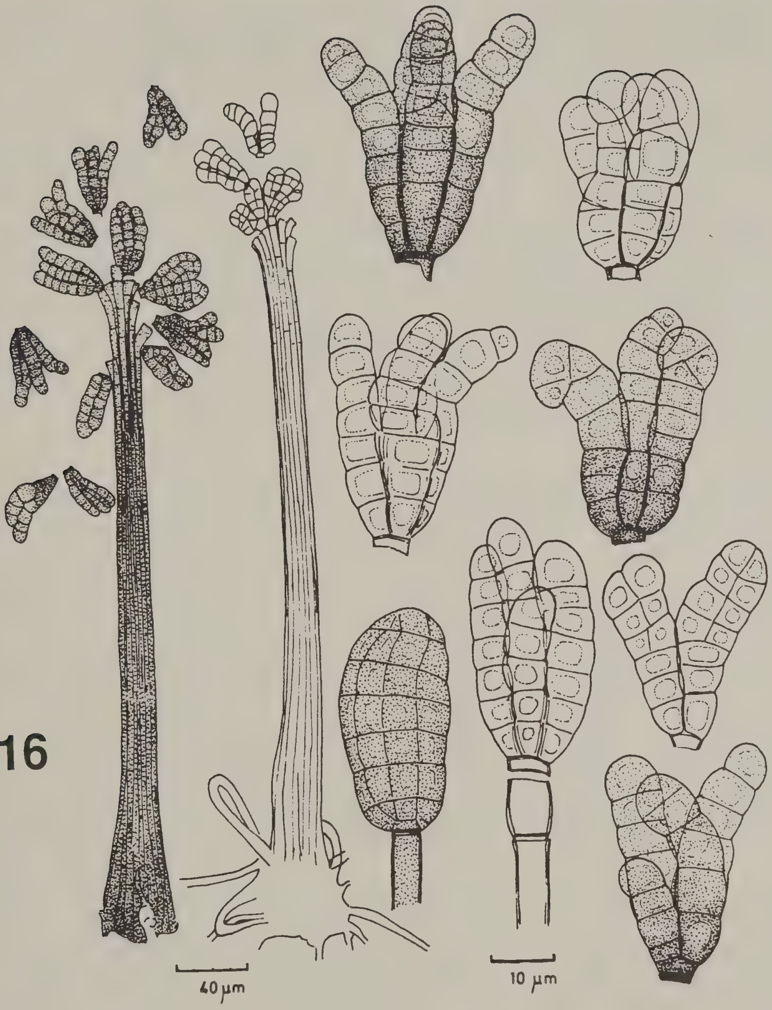


Fig. 16. *Kostermansinda andamanensis* anam.-sp. nov.: synnematal conidiomata and cheirosporous conidia.

*Kostermansinda andamanensis* differs unequivocally from the other species of *Kostermansinda* Rifai (1968) in that the upper part of each mature conidium is composed of diverging columns of cells: *K. magna* (Boedijn) Rifai and *K. minor* Cabello & Arambarri (Arambarri *et al.*, 1987) both produce ovoid to broadly ellipsoidal, dictyoseptate conidia

atrobrunneis, parallelis, septatis, laevibus, crassitunicatis, non-ramosis, atrobrunneis, 5-6.5 µm lat., composita. Cellulae conidiogenae integratae, terminales, monoblasticae, percurrenter renascentes, apice truncato et 8 µm lat. post secessionem conidiorum. Conidia solitaria, sicca, cheirosporosa, infra atrobrunnea, supra brunnea, laevia et crassitunicata, truncata ad basim, ex 2-4 columnis cellularum composita; quamquam multorum conidiorum juvenilium pars exterior relative laevis est et columnae cellularum connatae, tamen conidia matura inter cellulas sulcos non profundos praebent et partes apicales columnarum liberatae divergunt; cheirosporae 32-42 µm long., 5.5-8 µm lat. ad basim, 13-20 µm lat. in medio, et usque ad 36 µm lat. trans apices divergentes columnarum; columna unaquaeque ex (3-)6-7 cellulis euseptatis composita, 5-6.5 X 6.5-8 µm, ad septa leniter constricta. Conidia saepe per disruptionem rhexolyticam cellularum sustinentium liberantur.

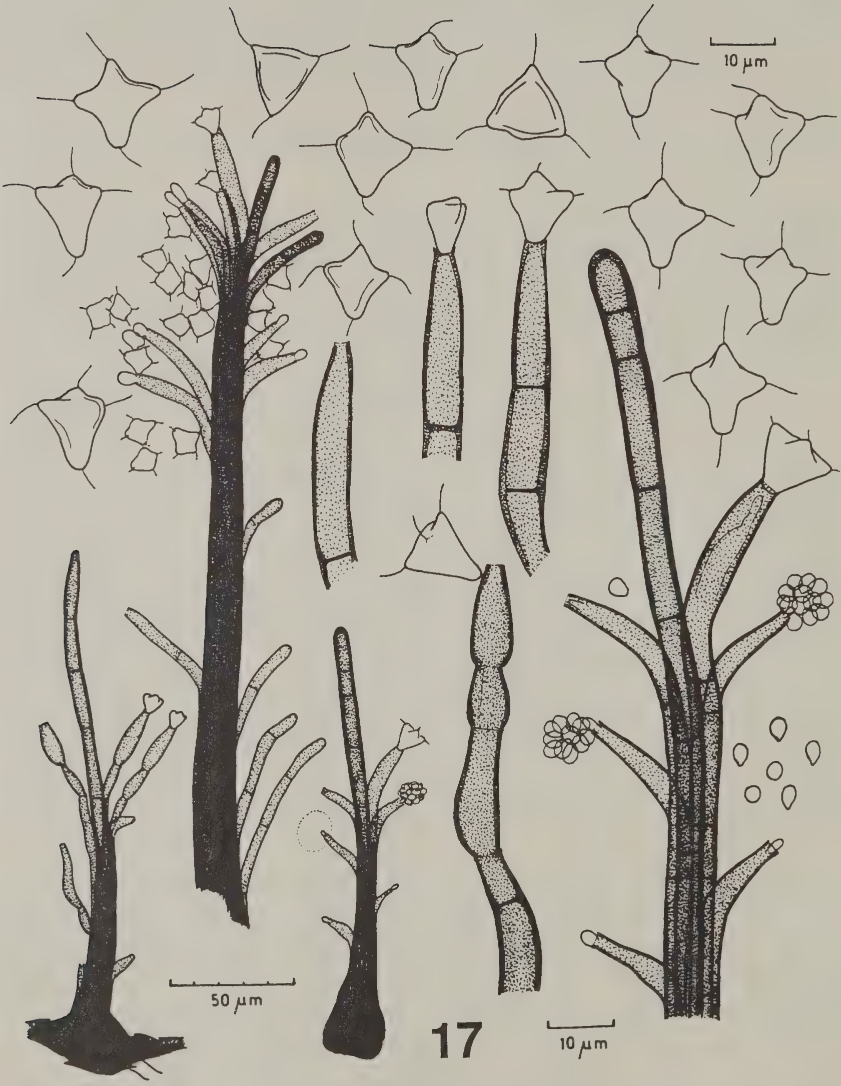
Conidial fungi, hyphomycetes. Colonies effuse, dark brown, velvety. Conidiomata synnematal, determinate, erect, dark brown, up to 420 µm long, 40-70 µm wide at the base, 15-30 µm wide in the middle and above, broadening at the apex into a fertile head 90 µm wide, composed of compactly and parallel, septate, smooth, thick-walled, unbranched, dark brown conidiophores 5-6.5 µm wide. Conidiogenous cells integrated, terminal, monoblastic, percurrently regenerating, truncate and up to 8 µm wide at the apex after conidium secession. Conidia solitary, dry, cheirosporous, dark brown below, medium brown above, smooth and thick-walled, truncate at the base, consisting of 2-4 columns of cells; although in many developing conidia the exterior is relatively smooth, and the cell columns still united up to their apices, mature conidia develop shallow furrows between the cells, and the apical parts of the columns become free and divergent; cheirospores are 32-42 µm long, 5.5-8 µm wide at the base, 13-20 µm wide in the middle and up to 36 µm wide across the divergent apices of the columns; each column is composed of (3-)6-7 euseptate cells, each cell 5-6.5 µm long and 6.5-8 µm wide, slightly constricted at the septa. The spores are often released by rhexolytic fracture of the supporting cell.
HOLOTYPE: on dead leaves of *Calamus* sp. (Arecaceae), Mt. Harriet, South Andaman Island, 5 May 1990, D.J. Bhat, Herb. DAOM 214606.
Teleomorph: unknown.

with a smooth outline. The similar genus *Kostermansindiopsis* Castañeda (1986) also has rounded dictyospores, and produces curved, tapering, needle-like accessory hyphae on the conidiogenous cells.

***Phialosporostilbe setosa*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 17)
(Etym. Latin: *seta* = a bristle)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, pilosae, albae usque griseo-brunneae. Conidiomata synnematica, erecta, recta vel flexuosa, 140-440 µm alt., 13-30 µm lat., ex 5-20 conidiophoris parallelis, contiguis, crassitunicatis, septatis, brunneis, apice fertili divergentibus composita; synnemata semper setam unam (raro plus quam unam) sterilem, atrobrunneam, laevem, crassitunicatam, obtusam, 160-450 µm alt., 5.5-8.5 µm lat., septis 15-20 µm distantibus; aequa vel longiora quam conidiophora et eis circumcincta. Cellulae conidiogenae terminales, integratae, monophialidicae, usque tripliciter percurrenter extensae, ex axe synnematis divergentes, pallide brunneae vel brunneae, cylindricae usque cylindrico-clavatae, 22-45 µm long., infra 5-7 µm lat., apice 3-4.5 µm lat., collarulum apicale inconspicuum ferentes. Conidia blastico-phialidica, in massis mucosis incoloratis aggregata; conidiorum sunt 2 formae: (1) conidia e cellulis conidiogenis superioribus oriunda, angularia, cuneiformia vel tetraradiata, 3 angulis protuberantibus et basi plusminusve truncata vel anguste rotundata praedita, non-septata, laevia, crassitunicata, incolorata; setula filosa, 5-7.5 µm long., in angulo unoquoque, praedita; (2) conidia e cellulis conidiogenis inferioribus oriunda, guttuliformia, basi anguste acuta praedita, non-septata, incolorata, laevia, 2-3.5 µm diam.

Conidial fungi, hyphomycetes. Colonies effuse, hairy, white to greyish brown. Conidiomata synnematal, erect, straight or flexuous, 140-440 µm tall, 13-30 µm wide, composed of 5-20 parallel, thick-walled, septate, brown conidiophores diverging at their fertile apices; synnemata indeterminate, always incorporating 1 (or rarely more than 1) sterile, dark brown, smooth, thick-walled, blunt seta 160-450 µm long, 5.5-8.5 µm wide, septa 15-20 µm apart; as long as or slightly longer than the conidiophores and surrounded by them. Conidiogenous cells terminal, integrated, monophialidic, extending percurrently up to 3 times, diverging from the main axis of the synnema, pale to medium brown, cylindrical to cylindric-clavate, 22-45 µm long, 5-7 µm wide below, 3-4.5 µm wide at the tip, with an inconspicuous apical collarette. Conidia blastic-phialidic, aggregating in colourless slimy masses and of two kinds: (1) conidia arising from the upper conidiogenous cells are angular, cuneiform, tetrahedral or tetraradiate, with 3 protuberant corners and a slightly



17

Fig. 17. *Phialosporostilbe setosa* anam.-sp. nov.: synnematal conidiomata, phialidic conidiogenous cells, tetraradiate, setulate conidia and microconidia.

truncate to rounded narrow base, non-septate, smooth, thick-walled, colourless, with dense cytoplasm, and on each corner having a thin setula, 5-7.5 µm long; (2) conidia arising from conidiogenous cells in the lower half of the synnema are drop-shaped, with a narrowly pointed base, non-septate, colourless, smooth, 2-3.5 µm diam.
HOLOTYPE: on decaying leaves of *Ochlandra* sp. (an endemic member of the Poaceae), Kudremukh, Shimogga District, Karnataka State, India, 30 Dec. 1989, D.J. Bhat, DAOM 214607. Teleomorph: unknown.

Mercado and Portales (1985) erected *Phialosporostilbe* for *P. turbinata* Mercado & Portales, a synnematous, phialidic hyphomycete with colourless, turbinate, angular conidia each bearing 3 apical setulae and sometimes 1 basal setula. In south India we have collected both *P. turbinata* and a possibly congeneric fungus, the mononematous *Nawawia filiformis* Marvanova (1980), which has angular, turbinate conidia with 3-4 apical setulae. It seems to us that a serious reassessment of these genera, and possibly also the mononematous, apically bisetulate *Chalarodes* McKenzie (1991) is warranted, but until this has been done, we prefer to dispose our fungus in *Phialosporostilbe*. The angular conidia of *P. setosa* resemble those of the type species. The major differences between the two species lie in the regular presence of one or more large, central setae in the synnema of *P. setosa* and especially in its development of a small-spored, phialidic *Chloridium*-like synanamorph on the lower part of the synnema.

***Phragmotrichum andamanense*** Bhat, Kendrick & Nag Raj
**anam.-sp. nov.** (Figs. 18, 19)
(Etym.: = pertaining to the Andaman Islands)

Ad fungos conidiales, Coelomycetes, pertinens. Caulicola. Conidiomata eustromatica, dissita, erumpentia, aspectu frontali doliiformia, initio clausa, post dehiscentia et quasi cupulata, atrobrunnea vel nigra, 120-160 X 100-135 µm; pariete membranaceo, ex textura porrecta composito, cellulis crassitunicatis, pallide brunneis, ex stratis cellularum 1-2 compositis; tela basali ex textura angulari composita, cellulis tenuitunicatis, incoloratis vel pallide brunneis. Hyphae conidiogenae e tela basali oriundae, plus minusve nodulosae, profuse ramosae, meristematicae, irregulatim septatae, plusminusve incoloratae vel pallide brunneae, tenuitunicatae, laeves. Conidia thallica, terminalia vel intercalaria, clavata vel fusiformia, apice et basi obtusa, laevia, dictyoseptata, septis transversalibus 10-15 et septis longitudinalibus 6-9, parte superiore lata et paene nigra, singula cellula apicali et cellulis in parte inferiore

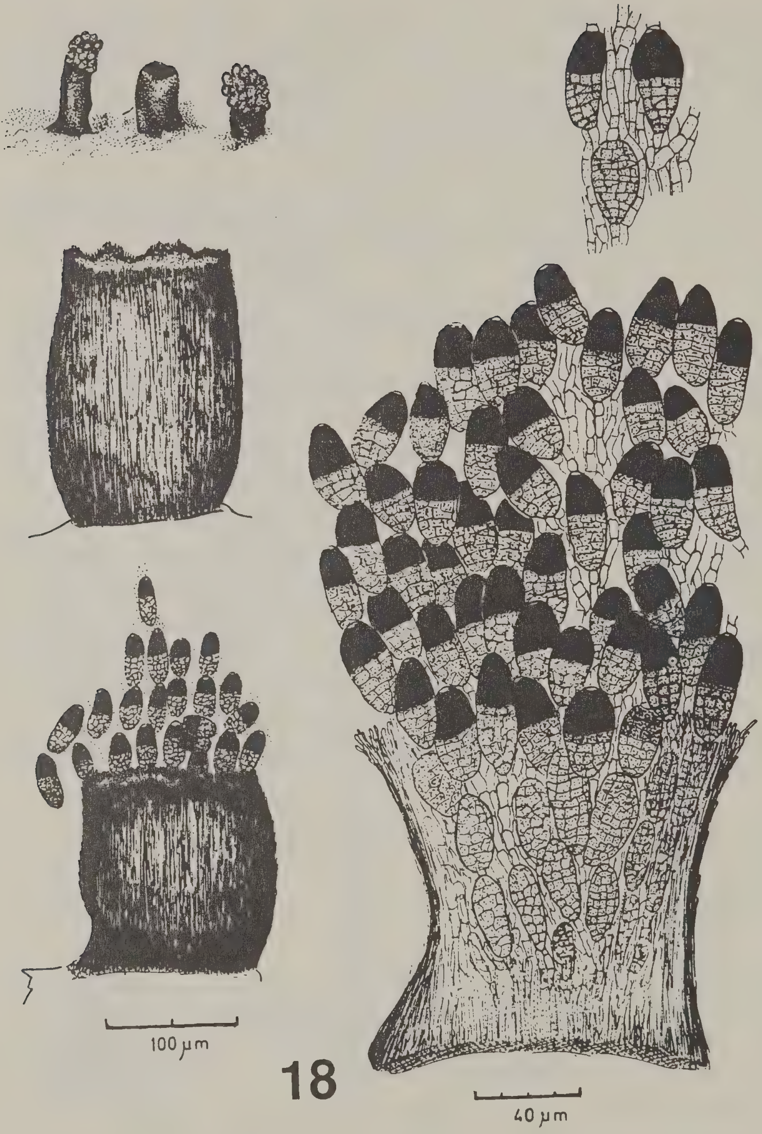


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Fig. 18. *Phragmotrichum andamanense* anam.-sp. nov.: cupulate, stromatic conidiomata and bicoloured, thallic, dictyosporous conidia.

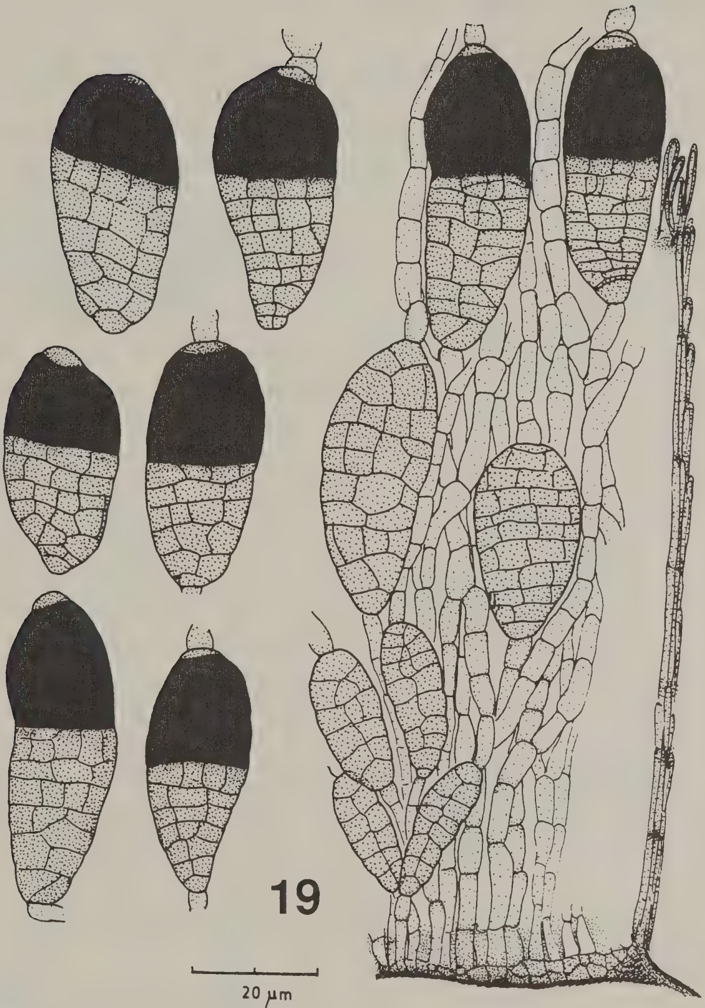


Fig. 19. *Phragmotrichum andamanense* anam.-sp. nov.: bicoloured, thallic, dictyosporous conidia.

pallidioribus, praedita; 35-50 X 16-20 µm.

Conidial fungi, Coelomycetes. Caulicolous. Conidiomata eustromatic, separate, erumpent, in surface view doliiform, initially closed but eventually opening and appearing cupulate, dark brown to black, 120-160 X 100-135 µm; wall membranous, of textura porrecta, cells thick-walled, pale brown, in 1-2 cell layers; basal tissue of textura angularis, cells thin-walled, colourless to pale brown. Conidiogenous hyphae arising from the basal tissue, more or less nodulose, profusely branched, meristematic, irregularly septate, almost colourless to medium brown, thin-walled, smooth. Conidia thallic, terminal or intercalary, clavate to fusiform with obtuse ends, smooth-walled, dictyoseptate with 10-15 transverse septa and 6-9 longitudinal septa, broad and almost black in the upper half, a single apical cell and the cells in the lower half paler; 35-50 X 16-20 µm.
HOLOTYPE: on dead twigs of *Strobilanthes* sp. (Acanthaceae), Mt. Harriet, South Andaman Island, 5 May 1990, D.J. Bhat, DAOM 214609.
Teleomorph: unknown.

Sutton (1980) accepted four species in the genus *Phragmotrichum* Kunze: *P. chailletii* Kunze (the type species), *P. pini* (Cooke) Sutton & Sandhu, *P. platanoidis* Otth, and *P. rivoclarinum* (Peyronel) Sutton & Pirozynski. *Phragmotrichum andamanense* differs from all four in the following characters: (1) the eustromatic conidioma is doliiform to cupulate; (2) the conidiogenous cells are irregularly septate, meristematic and develop from nodulose basal tissue cells; (3) the conidia are clavate to fusiform, broad and almost black in the upper half, a single apical cell and the cells in the lower half paler; (4) the conidia measure 35-50 X 16-20 µm.

***Piricaudiopsis appendiculata*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 20)
(Etym. Latin: *appendiculatus* = with appendages)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, olivaceae vel atrobrunneae, pilosae. Mycelium in substrato immersum. Conidiophora mononematica, discreta, erecta, recta vel flexuosa, non-ramosa, laevia, crassitunicata, usque ad 620 µm alt., 18-35 µm lat. ad basim, 13-18 µm lat. in medio, 7-11.5 µm lat. ad apicem, 4-8-septata. Cellulae conidiogenae integratae, terminales, interdum laterales, post secessionem conidiorum truncatae. Conidia solitaria, sicca, flabelliformia, interdum bi- vel tri-lobata, lenticularia, dictyoseptata, ex columnis cellularum radiantia, atrobrunnea, 50-80 µm alt., 60-90 µm lat., 15-22 µm cr. in medio appendicibus 2-4 longis, divergentibus, angustis, 75-120 µm long., laevibus, praedita; pars inferior 3-5-septata, 4-6 µm lat., brunnea;

**20**

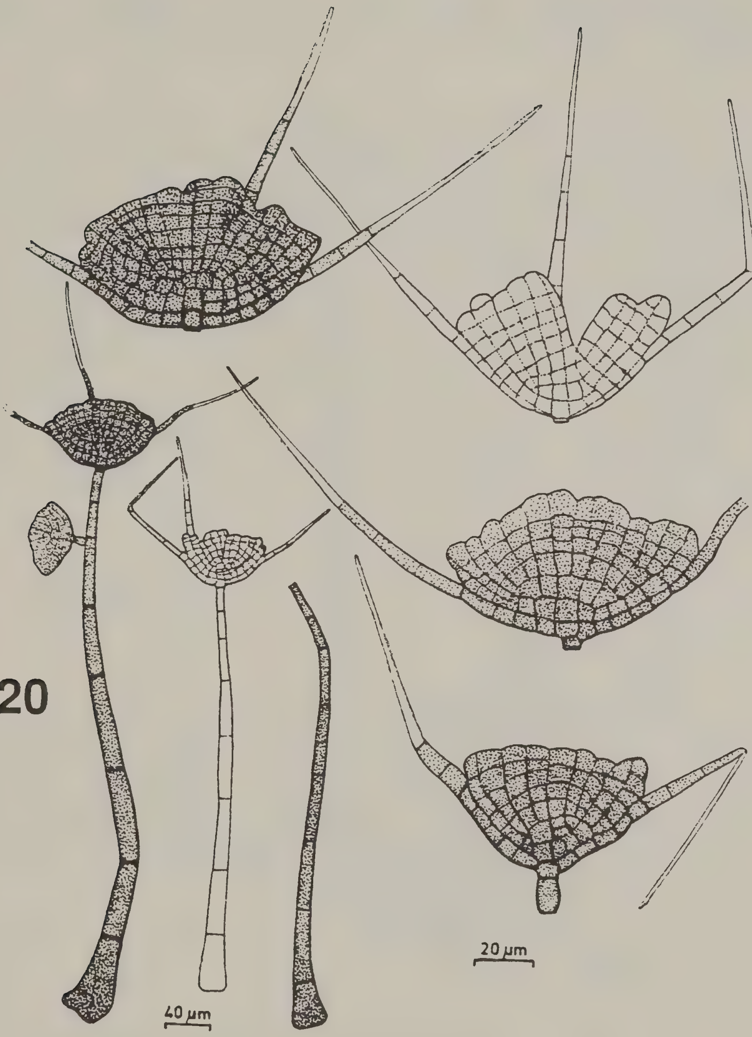


Fig. 20. *Piricaudiopsis appendiculata* anam.-sp. nov.: conidiophores and fan-shaped, appendaged, dictyosporous conidia.

pars superior incolorata, angustata ad 1.5-2 µm lat., ex columnis externis cellularum conidiorum, et in ambobus angulis et in utrisque lateribus, exoriunda.

Conidial fungi, hyphomycetes. Colonies effuse, olivaceous to dark brown, hairy. Mycelium immersed in the substrate. Conidiophores mononematous, differentiated, erect, straight or flexuous, unbranched, smooth, thick-walled, up to 620 µm long, 18-35 µm wide at the base, 13-18 µm wide in the middle, 7-11.5 µm wide at the apex, 4-8-septate. Conidiogenous cells integrated, terminal, sometimes lateral, truncate after conidium secession. Conidia solitary, dry, fan-shaped, sometimes two- or three-lobed, lenticular in edge view, dictyoseptate, with rows of cells radiating from a protuberant basal cell 6-7.5 µm wide, dark brown, 50-80 µm high, 60-90 µm wide, 15-22 µm thick in the middle; with 2-4 long, divergent, tapering, appendages 75-120 µm long, smooth, lower half 3-5-septate, 4-6 µm wide, brown, and apically colourless tapering to 1.5-2 um wide; appendages arising from outermost rows of cells on the main body of the conidium, on both corners and on either side.
HOLOTYPE: on dead twigs, Kudremukh, Karnataka State, India, 7 July 1989, D.J. Bhat, DAOM 214610.
Teleomorph: unknown.

*Piricaudiopsis appendiculata* differs from *P. elegans* Portales & Mercado, the type species of *Piricaudiopsis* Portales & Mercado (1987), in the long hyphal appendages on the conidia: those in *P. elegans* are very short. *Ceratosporella fertilis* Castañeda (1985) could also possibly be disposed in *Piricaudiopsis*, but the rows of cells constituting its conidia are separate, and the occasional apical appendage is filiform.

***Selenodriella indica*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 21)
(Etym. = pertaining to India)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, brunneae, hypophyllae. Mycelium plerumque immersum, ex hyphis septatis, ramosis, paene incoloratis, 2-4 µm lat., compositum. Conidiophora macronemata, mononematica, erecta, recta vel flexuosa, atrobrunnea, crassitunicata, 110-220 X 5-8 µm, 8-14-septata, percurrenter renascentia; basis similis rhizomati, contorta, vermiformis, ad 15 µm lat., arcte septata, atrobrunnea, valde crassitunicata, laevis. Cellulae conidiogenae blastico-sympodiales, discretae, verticillatim vel aggregate ad apicem conidiophori oriundae, lageniformes, denticulatae, 8-10 µm long., usque ad 5 µm lat. ad basim, 2-2.5 µm lat. ad apicem fertilem,

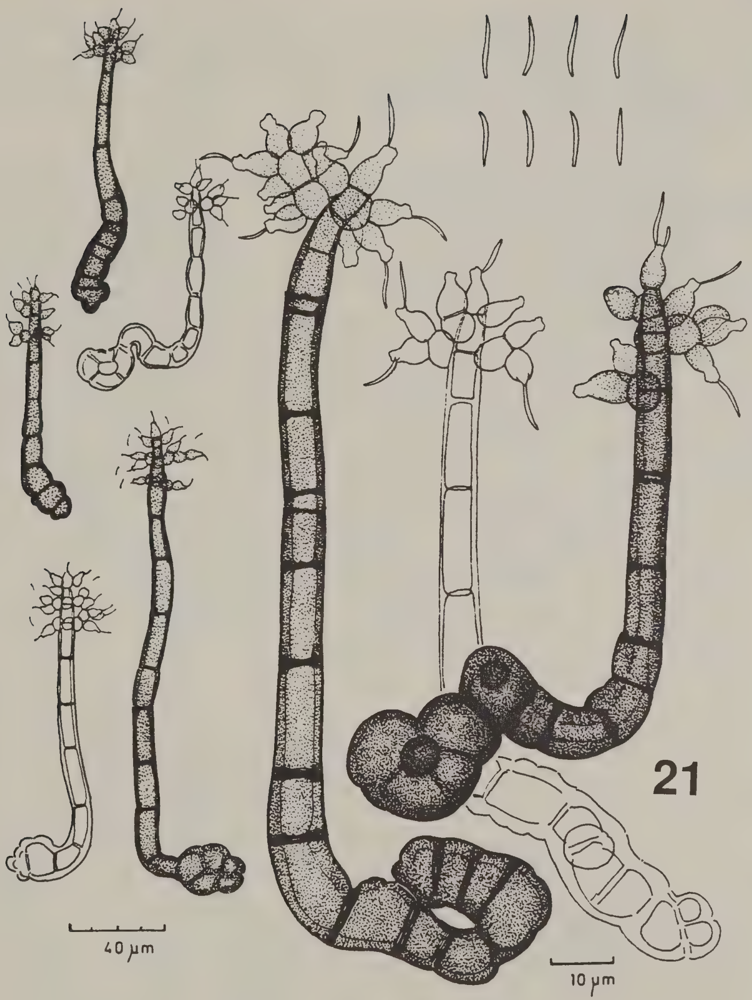


Fig. 21. *Selenodriella indica* anam.-sp. nov.: contorted conidiophores, apically clustered sympodial conidiogenous cells, and falcate conidia.

tenuitunicatae, basi pallide brunneae, supra hyalinae, vel e conidiophoris, vel e ramis 0-1-septatis vel e cellula terminali, oriundae. Conidia blastico-sympodialia, falcata, laevia, hyalina, non-septata, utrinque acuta, 7-10 X 0.5-1 µm.

Conidial fungi, hyphomycetes. Colonies effuse, brown, hyphophyllous. Mycelium mostly immersed, composed of septate, branched, almost colourless hyphae 2-4 µm wide. Conidiophores differentiated, mononematous, erect, straight or flexuous, dark brown, thick-walled, 110-220 X 5-8 µm, 8-14-septate, regenerating percurrently; base rhizome-like, contorted, vermiform, up to 15 µm wide, closely septate, dark brown, very thick-walled, smooth. Conidiogenous cells blastic-sympodial, discrete, developing in whorls or clusters at the tip, lageniform, with minute denticles, 8-10 µm long, up to 5 µm wide at the base, 2-2.5 µm wide at the fertile apex, thin-walled, pale brown at the base, colourless at the upper half, arising directly on conidiophores, from 0-1-septate branches or from the terminal cell. Conidia blastic-sympodial, falcate, smooth, colourless, non-septate, pointed at both ends, 7-10 X 0.5-1 µm.
HOLOTYPE: on dead leaves, Mt. Harriet, South Andaman Island, India, 5 May 1990, D.J. Bhat, DAOM 214611.
Teleomorph: unknown.

*Selenodriella* Castañeda & Kendrick (1990b) essentially combines the characters of *Selenosporella* Arnaud: MacGarvie (1968) and *Idriella* Nelson & Wilhelm (1956) in its conidiophore, conidiogenous cells and conidium morphology. Three species have so far been assigned to this genus: *S. fertilis* (Pirozynski & Hodges) Castañeda & Kendrick (the type species), *S. intermedia* Castañeda & Kendrick, and *S. perramosa* Castañeda & Kendrick. *Selenodriella indica* is unique in that: (1) the conidiogenous cells arise only on the apical region of the conidiophore, while in the other species they are distributed along the axis; (2) the conidiophore bases are thickened and coiled or contorted, assuming a rhizome-like appearance, while in the other species they are lobed.

*Spadicoides goanensis* Bhat & Kendrick **anam.-sp. nov.** (Fig. 22)
(Etym. = pertaining to Goa State, India)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae gregariae, effusae, olivaceae vel brunneae, hypophyllae. Conidiophora mononematica, discreta, 6-18 aggregata, erecta, recta vel in medio curvata, crassitunicata, non-ramosa, 160-200 µm alt., ad basim 4-8-lobata et inflata usque ad 15 µm lat., 6-8.5 µm lat. supra, 3-5-septata, infra

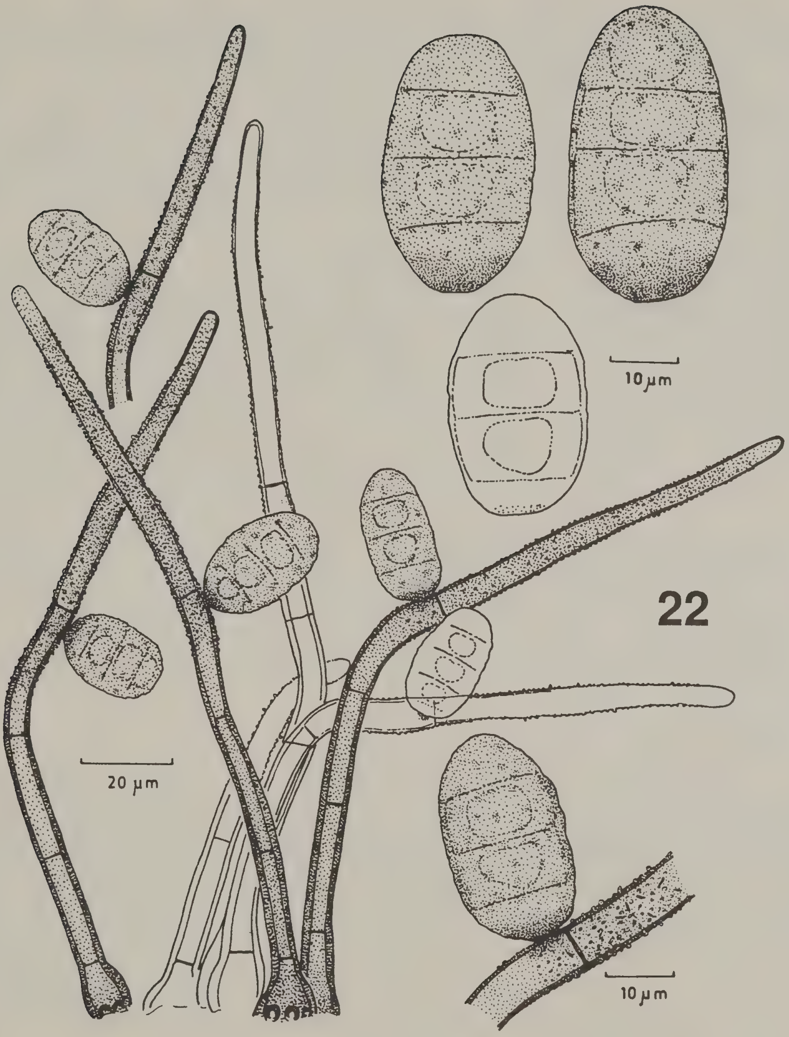

10 µm
22
20 µm
10 µm

Fig. 22. *Spadicoides goanensis* anam.-sp. nov.: setose conidiophores and tretic, phragmosporous conidia.

laevia, supra verrucosa, olivacea vel atrobrunnea; versus apicem pallescentia, laevia, rotundata. Cellulae conidiogenae intercalares, integratae, monotreticae, poro uno, indistincto, minuto, simplici, infra septum superius praeditae; 25-32 X 6-8.5 µm, supra verrucosae, infra laeves. Conidia solitaria, sicca, cylindrico-ovoidea vel oblonga, 3-pseudoseptata, cellulis duabus centralibus crassitunicatis, lumine reducto, verruculosa, brunnea vel atrobrunnea, basi atrantia, 23-40 X 14-22 µm.

Conidial fungi, hyphomycetes. Colonies gregarious, effuse, olivaceous to brown, hypophyllous. Conidiophores mononematous, differentiated, arising in groups of 6-18, erect, straight or curved in the middle, thick-walled, unbranched, 160-200 µm long, 4-8-lobed and inflated at the base up to 15 µm wide, 6-8.5 µm wide above, 3-5-septate, lower part smooth, upper part verrucose, olivaceous to dark brown, paler, smooth and rounded at the tip. Conidiogenous cells intercalary, integrated, monotretic, with a single, indistinct, minute, simple pore just below the upper septum, 25-32 X 6-8.5 µm, upper half verrucose, lower half smooth. Conidia solitary, dry, cylindric-ovoid to oblong, 3-pseudoseptate, central 2 cells thick-walled with reduced lumen, verruculose, medium to moderately dark brown, darker at the base, 23-40 X 14-22 µm.
HOLOTYPE: on decaying leaves, Morphirla, Goa, India, 28 July 1991, D.J. Bhat, DAOM 214612.
Teleomorph: unknown.

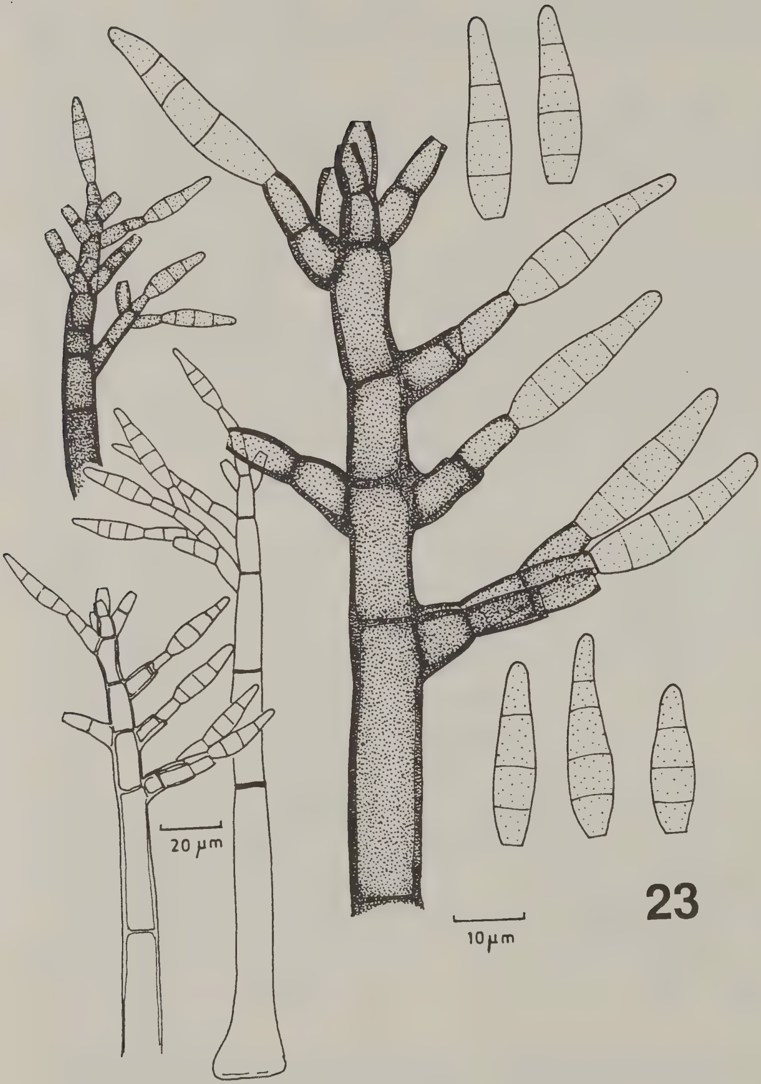
In a reassessment of the genera *Spadicoides* Hughes (1958) and *Diplococcium* Grove (1885), Sinclair, Eiker and Bhat (1985), rejected the branching of conidiophores as a diagnostic generic character and separated the two genera only on their respectively solitary or catenate conidia. The generic descriptions were emended accordingly. Kuthubutheen and Nawawi (1991a) reviewed the taxonomy of *Spadicoides* and provided a key to the 16 accepted species. Among these, only *S. curvularioides* Sutton & Hodges, with its large (22-33 x 6-7.5 µm), verruculose, 3-septate conidia, and *S. xylogena* (A.L. Smith) Hughes, also with large (16-34 x 7-10.5 µm), smooth, 3-septate conidia, resemble *S. goanensis*. However, *S. goanensis* differs from these and all other species of *Spadicoides* in: (1) its partly verrucose conidiophores, (2) the presence of only one, monotretic conidiogenous cell on each conidiophore, (3) the production of only a single conidium by the conidiogenous cell.

***Sporidesmiopsis goanensis*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 23)
(Etym. = pertaining to Goa State, India)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, atrobrunneae, pilosae. Mycelium plerumque immersum. Conidiophora mononematica, discreta, erecta, recta vel flexuosa, atrobrunnea usque nigra, laevia, crassitunicata, usque ad 220 µm alt., basi inflata 20-25 µm lat., apice usque ad 10 µm lat., usque ad 10-septata, in dimidio superiore infra septa ramosa; rami percurrenter semel aut bis extensi, crassitunicati, 1-2-septati, laeves, atrobrunnei, 20-30 X 5-10 µm. Cellulae conidiogenae integratae, apicales in axe principali et ramis, anguste doliiformes, post secessionem conidiorum apice truncatae, 7.5-10 X 5.5 µm. Conidia solitaria, sicca, obclavata vel fusiformia, saepe leniter curvata, basi truncata, apice rotundata, pallide brunnea, laevia, 20-30 µm long., infra medium 5-7 µm lat., basi et apice 2-3 µm lat., 3-4-septata.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown, hairy. Mycelium mostly immersed. Conidiophores mononematous, differentiated, erect, straight or flexuous, dark brown to black, smooth, thick-walled, up to 220 µm tall, 20-25 µm wide at the swollen base, up to 10 µm wide at the tip, up to 10-septate, branched below septa in the upper half; branches extending percurrently 1-2 times, thick-walled, 1-2-septate, smooth, dark brown, 20-30 X 5-10 µm. Conidiogenous cells integrated, apical on main stipe and branches, narrowly doliiform, truncate at the apex after conidium secession, 7.5-10 X 5.5 µm. Conidia solitary, dry, obclavate to fusiform, often slightly curved, base truncate, apex rounded, pale brown, smooth, 20-30 µm long, 5-7 µm wide just below the middle, 2-3 µm wide at base and apex, 3-4-septate.
HOLOTYPE: on dead twigs, Kodachadri Hills, Karnataka, India, D.J.Bhat, 12 Aug. 1991, DAOM 214613.
Teleomorph: unknown.

Subramanian and Bhat (1987) introduced two new monotypic genera, *Sporidesmina* Subram. & Bhat (type species: *S. malabarica* Subram. & Bhat) and *Sporidesmiopsis* Subram. & Bhat (type species: *S. malabarica* Subram. & Bhat), conidiogenesis in both being similar to that in most species classified in *Sporidesmium* Link ex Fries. The three genera are distinguishable as follows: the conidiophores in *Sporidesmium* are mononematous and unbranched, and the conidiogenous cells are integrated; in *Sporidesmina* the conidiophores are synnematous and carbonaceous and the conidia are partly euseptate and partly distoseptate. (It could be argued that *Sporidesmina* is separated from *Sporidesmium*



**23**

Fig. 23. *Sporidesmiopsis goanensis* anam.-sp. nov.: apically branched conidiophores, terminal, monoblastic conidiogenous cells, and phragmosporous conidia.

only by the aggregation of its conidiophores into synnemata, but *Sporidesmium* is such a large and obviously heterogeneous genus that the spinning off of segregate genera is bound to continue.) In *Sporidesmiopsis*, the conidiophores are mononematous with apical branches, and conidiogenous cells arise on both stipe and branches. In the *Sporidesmium-Sporidesmina-Sporidesmiopsis* complex, our fungus, with its apically branched, mononematous conidiophores, fits into *Sporidesmiopsis*. However, it differs from the type species in shape, septation, pigmentation and dimensions of conidia.

Crane and Dumont (1978) described a new species of hyphomycete from Venezuela as *Brachysporiella dennisii*. This fungus was also reported from Cuba by Mercado (1984), and is clearly identical with the type species of *Sporidesmiopsis*, *S. malabarica* Subramanian & Bhat (1987). This provides an older epithet for *S. malabarica*. We accordingly make the required new combination:

***Sporidesmiopsis dennisii*** (Crane & Dumont) Bhat, Kendrick & Nag Raj **comb. nov.**
≡ *Brachysporiella dennisii* Crane & Dumont,
Can. J. Bot. **56**:2613. 1978.
= *Sporidesmiopsis malabarica* Subramanian & Bhat,
Kavaka **15**: 71-74. 1987.

***Sporoschisma uniseptatum*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 24)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, nigrae, velutinae. Conidiophora mononematica, discreta, erecta, recta vel flexuosa, 140-205 µm alt., 10-12.5 µm lat., 1-2-septata, non-ramosa, crassitunicata, atrobrunnea, ex stromatibus atrobrunneis, usque ad 65 µm diam., oriunda. Hyphae steriles capitatae ex stromatibus oriundae, erectae, flexuosae, brunneae, laeves, usque ad 175 µm alt., 8-10 µm lat., ad apicem expansum usque ad 12.5 µm lat., 3-6-septata, 2-3 percurrenter renascentes. Cellulae conidiogenae phialidicae, usque ad 160 µm long., terminales, integratae, crassitunicatae, atrobrunneae, ex ventre leniter inflato ad 22 µm lat., et collarulo tubuliformi, 70-80 X 12-16.5 µm, compositae. Conidia blastico-phialidica, cylindrica, utrinque truncata, 1-septata, raro 2-septata, crassitunicata, verruculosa, pallide brunnea, 27-32 X 11-12.5 µm, saepe 10-15 conidiorum pseudocatenam mucosam formantia.

Conidial fungi, hyphomycetes. Colonies effuse, black, velvety.

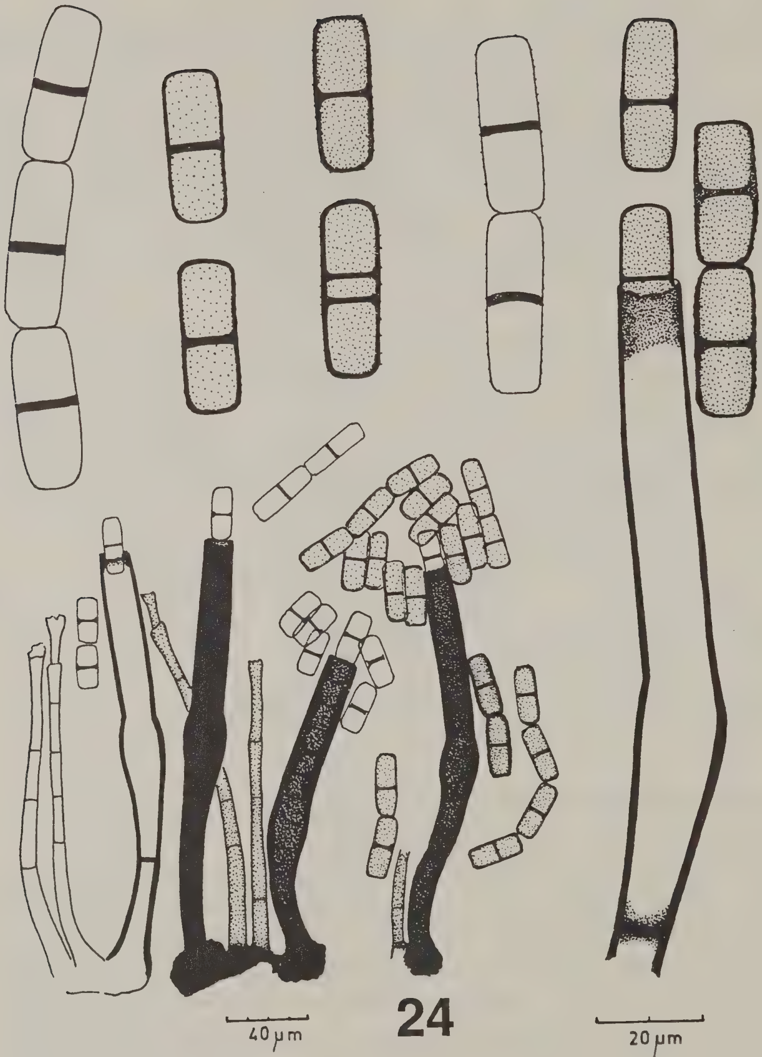


Fig. 24. *Sporoschisma uniseptatum* anam.-sp. nov.: conidiophores with large apical phialides, deep, tubular collarettes, and cylindrical, didymosporous conidia.

Conidiophores mononematous, differentiated, erect, straight or flexuous, 140-205 µm tall, 10-12.5 µm wide, 1-2-septate, unbranched, thick-walled, dark brown, arising from dark brown stromata up to 65 µm across. Sterile capitate hyphae arising from the same stromata, erect, flexuous, medium brown, smooth, up to 175 µm tall, 8-10 µm wide, up to 12.5 µm wide at flared apex, 3-6-septate, regenerating percurrently 2-3 times. Conidiogenous cells phialides, up to 160 µm long, terminal, integrated, thick-walled, dark brown, consisting of a slightly swollen venter up to 22 µm wide and a tubular collarette 70-80 X 12-16.5 µm. Conidia blastic-phialidic, cylindrical, truncate at both ends, 1-septate, very rarely 2-septate, thick-walled, verruculose, pale brown, 27-32 X 11-12.5 µm, often in slimy false chains of 10-15 conidia.
HOLOTYPE: on decaying twigs, Morphirla, Goa, India, 28 July 1991, D.J. Bhat, DAOM 214614.
Teleomorph: unknown.

The conidia of *S. uniseptatum* may be compared with those of *S. juvenile* Boudier (Ellis, 1971), which are also verruculose, but while those of *S. juvenile* are regularly 3-septate, those of *S. uniseptatum* are just as regularly 1-septate. This feature distinguishes *S. uniseptatum* from all other species of *Sporoschisma* Berkeley & Broome (Hughes, 1966).

***Uberispora tropicalis*** Bhat & Kendrick **anam.-sp. nov.** (Fig. 25)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, griseobrunneae, velutinae. Conidiophora mononematica, erecta, recta vel flexuosa, pallide brunnea, 3-7-septata, septis 8-23 µm distantibus, raro ramosa, usque ad 4-plo percurrenter renascentia, 40-150 µm alt. et sursum gradatim attenuata, ad basim leniter inflatam ad 8-11 µm lat., in medio 4-5.5 µm lat., 2.5-3.5 µm lat. ad apicem. Cellulae conidiogenae integratae, terminales, monoblasticae, cylindricae, paene incoloratae, 10-30 µm long. Conidia solitaria, sicca, dictyoseptata, septis conspicuis 4-5, raro 6, crassis et atris; 20-23 µm diam., ex cellulis 3 formarum composita: (1) cellula centralis solitaria, crassitunicata, atrobrunnea, laevis, angularis, 12-18 µm diam.; (2) cellulae laterales 3-4, paene incoloratae, conicae, apicibus obtusis, basibus truncatis, 5-10 X 4.5-7 µm; (3) cellula basalis conico-truncata, 5-8 X 3-6 µm; schizolytice secedens, saepe partem superiorem apicalis cellulae conidiogenae quasi fimbriam basalem ferens. Interdum conidia secessa ad latera conidiophori per vestigium parietis adhaerent.

Conidial fungi, hyphomycetes. Colonies effuse, greyish-brown, velvety. Conidiophores mononematous, erect, straight or flexuous, pale brown, 3-

**25**

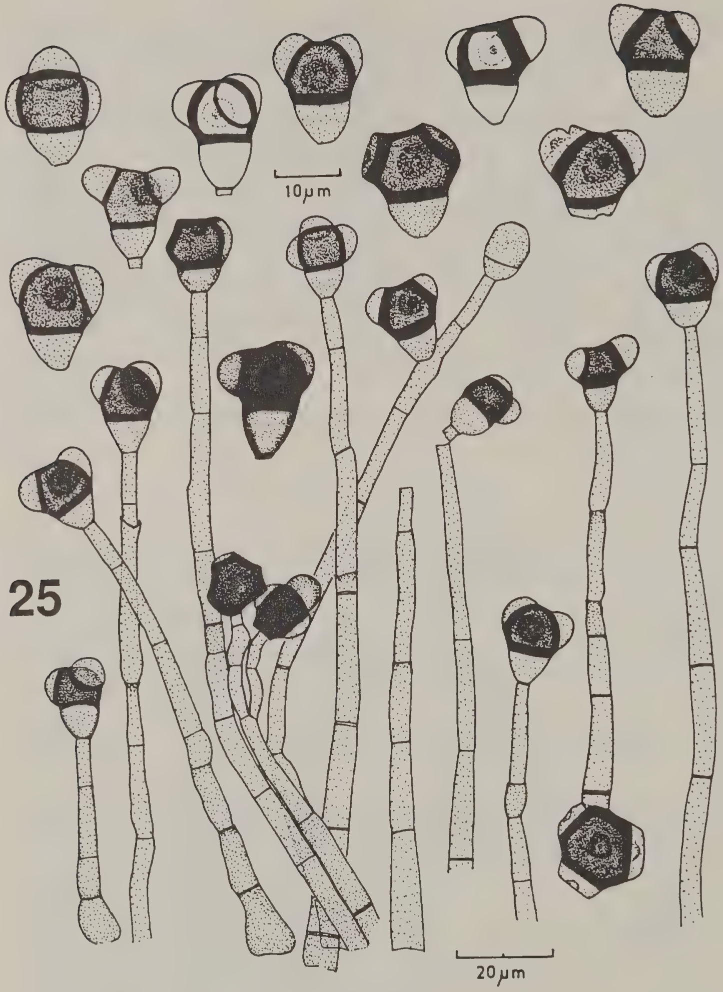


Fig. 25. *Uberispora tropicalis* anam.-sp. nov.: conidiophores and solitary, apical, lobed conidia.

7-septate, septa 8-23 µm apart, rarely branched, percurrently regenerating 3-4 times, 40-150 µm long, and gradually tapering upward, 8-11 µm wide at the slightly inflated base, 4-5.5 µm wide in the middle, 2.5-3.5 µm wide at the tipe. Conidiogenous cells integrated, terminal, monoblastic, cylindrical, almost colourless, 10-30 µm long. Conidia solitary, dry, septate, 20-22.5 µm diam., with a central thick-walled, dark brown, smooth, angular cell, 12-18 µm diam., and 3 lateral, almost colourless, conical cells with obtuse apices and truncate base 5-10 X 4.5-7 µm, with a conico-truncate basal cell 5-8 X 3-6 µm, often carrying the upper portion of the conidiogenous cell as a basal frill, seceding schizolytically. Seceded conidia sometimes remain attached to the side of the conidiophore by a wall remnant.
HOLOTYPE: on dead twigs, Donigalu, Hassan District, Karnataka State, India, 28 Oct. 1989, D.J. Bhat, DAOM 214615.
Teleomorph: unknown.

The genus *Uberispora* Pirozynski & Hodges (1973), until now represented only by the type species, *U. simplex* (Ichinoe) Pirozynski & Hodges, is characterized by complex, dictyoseptate conidia with a central, thick-walled, dark brown, angular cell surrounded by several conical cells with narrow apices. *Uberispora tropicalis* differs from *U. simplex* in several qualitative characters: (1) almost all conidia of *U. tropicalis* lack an apical cell; (2) the peripheral cells on the conidium of *U. simplex* narrow to a pointed apex, while in *U. tropicalis* they have obtuse apices; (3) in *U. tropicalis* the peripheral cells of older conidia often collapse.

*Uberispora tropicalis* may also be compared with *Uvarispora* Goos & Pirozynski (1975), and with *Sopagraha* Subramanian & Sudha (1979). However, *Uvarispora lignicola* Goos & Pirozynski, the type species of *Uvarispora*, produces sporodochial conidiomata, with slimy, colourless conidia. Conidia of *Sopagraha sibika* Subramanian & Sudha also have central and peripheral cells, but always have more than one central cell, the central cells bear up to 12 apiculate peripheral cells, and these in turn bear smaller satellite cells.

Many years ago, the junior author described a new species of *Hormodendrum* (Kendrick, 1961) (subsequently transferred to *Cladosporium* by Ellis, 1976) which differed from many other species of *Cladosporium* mainly in the presence of a darkly pigmented, chlamydosporous synanamorph. Although no name was provided for this synanamorph, the chlamydospores resembled those of *Uberispora* in having a central cell with two rounded lateral cells, a rounded apical cell, and a conico-truncate basal cell. These propagules were usually sessile, but their cruciate appearance was reminiscent of *Uberispora*. When the genera of hyphomycetes are rationalized, this similarity will have to be taken into account.

***Vanakripa*** Bhat, Kendrick & Nag Raj **anam.-gen. nov.**
(Etym. Sanskrit: *Vanakripa* = gift of the forest)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, nigrae, velutinae. Mycelium partim superficiale et partim in substrato immersum, ex hyphis septatis, ramosis, incoloratis vel pallide brunneis, plusminusve crassitunicatis, compositum. Conidiomata sporodochialia ex stromatibus pseudoparenchymaticis oriunda. Conidiophora mononematica, conspicua, erecta, flexuosa, incolorata, septata, ramosa, laevia, saepe septis crassis, refractilibus, praedita. Cellulae conidiogenae holoblasticae, obpyriformes, clavatae, incoloratae, curvatae, versus septa basalia angustatae, post secessionem conidiorum truncatae. Conidia clavata vel obpyriformia, ad apicem rotundata, ad basim truncata, atrobrunnea vel nigra, laevia, crassitunicata, 0-1-septata.

Conidial fungi, hyphomycetes. Colonies effuse, black, velvety. Mycelium partly immersed, partly superficial, composed of septate, much branched, colourless to pale brown, moderately thick-walled hyphae. Conidiomata sporodochial, arising from pseudoparenchymatous stromata. Conidiophores differentiated, erect, flexuous, colourless, septate, branched, smooth, often with thick, refractile septa. Conidiogenous cells holoblastic, obpyriform, clavate, colourless, often curved, narrowed toward the base, truncate after conidial secession. Conidia clavate to obpyriform, rounded at the tip, truncate at the base, darkly pigmented, smooth, thick-walled, 0-1-septate.
Type species: *V. gigaspora*.

Few fungi resemble *Vanakripa*. Although *Bactrodesmium* Cooke (Ellis, 1971) is also sporodochial, and accommodates some taxa with large, rounded, darkly pigmented conidia, those conidia are phragmoseptate, and their subtending structures look like rather undifferentiated hyphae. The conidia of *Vanakripa* are 0-1-septate, and their subtending structures are highly diagnostic. The cells of the conidiogenous hyphae are characteristically swollen and thin-walled, though the septa tend to be narrow and thickened. In *V. gigaspora*, the cells of the conidiogenous hyphae tend to be swollen toward the apex, at times looking like raquette hyphae of some keratinophilic members of the Onygenales (Currah, 1985).

***Vanakripa gigaspora*** Bhat, Kendrick & Nag Raj **anam.-sp. nov.** (Fig. 26)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, nigrae, velutinae, corticolae. Mycelium partim immersum, partim superficialem, ex hyphis septatis, ramosis, incoloratis usque pallide brunneis, leniter crassitunicatis, laevibus, 2.5-4 µm lat., compositum. Conidiophora discreta, erecta, flexuosa, incolorata, usque ad 110 µm alt., 4-5 µm lat., septata, ramosa, laevia; septa angusta, crassa, saepe cum zona incrassata refractiva consociata, spisse et paene parallele in sporodochiis usque ad 120 µm diam., usque ad 400 µm alt., disposita, ex stromate pseudoparenchymatico usque ad 300 µm diam., enascentia. Cellulae conidiogenae obpyriformes, incoloratae, curvatae, 12.5-40 µm long., supra 5-10 µm lat., ad basim 2-3 µm lat., laeves, apice post secessionem conidiorum truncatae. Conidia clavata vel obpyriformia, apice rotundata, basi truncata, fuscantia, 32-43 X 18-22 µm, laevia, crassitunicata, septo submediali praedita; cellula apicalis grandis, 30-38 µm long., cellula basalis parva 3-5 µm long.

Conidial fungi, hyphomycetes. Colonies effuse, black, velvety, corticolous. Mycelium immersed and superficial, composed of septate, much branched, colourless to pale brown, smooth hyphae 2.5-4 µm wide. Conidiophores differentiated, erect, flexuous, colourless, up to 110 µm long, 4-5 µm wide, septate, branched, smooth; septa narrow, thick, often associated with a narrow, circular, refractile zone and giving an appearance of raquette hyphae; arranged compactly and almost parallel in sporodochia up to 120 µm diam., up to 400 µm tall, arising from a pseudoparenchymatous stroma up to 300 µm wide. Conidiogenous cells holoblastic, obpyriform, colourless, curved, 12.5-40 µm long, 5-10 µm wide above, 2-3 µm wide at the base, smooth, truncate at the tip after conidium secession. Conidia clavate to obpyriform, rounded at the tip, truncate at the base, darkly pigmented, 32-43 X 18-22 µm, smooth, thick-walled, apiosporous, with a submedian septum delimiting a large apical cell 30-38 µm long, and a small basal cell 3-5 µm long.
HOLOTYPE: on dead twigs, Molem Wildlife Sanctuary, Goa, India, 30 June 1991, D.J. Bhat, DAOM 214616.
Teleomorph: unknown.

***Vanakripa parva*** Bhat, Kendrick & Nag Raj **anam.-sp. nov.** (Fig. 27)
(Etym. Latin: *parvus* = small)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, nigrae, velutinae, corticolae. Mycelium partim immersum, partim superficiale,

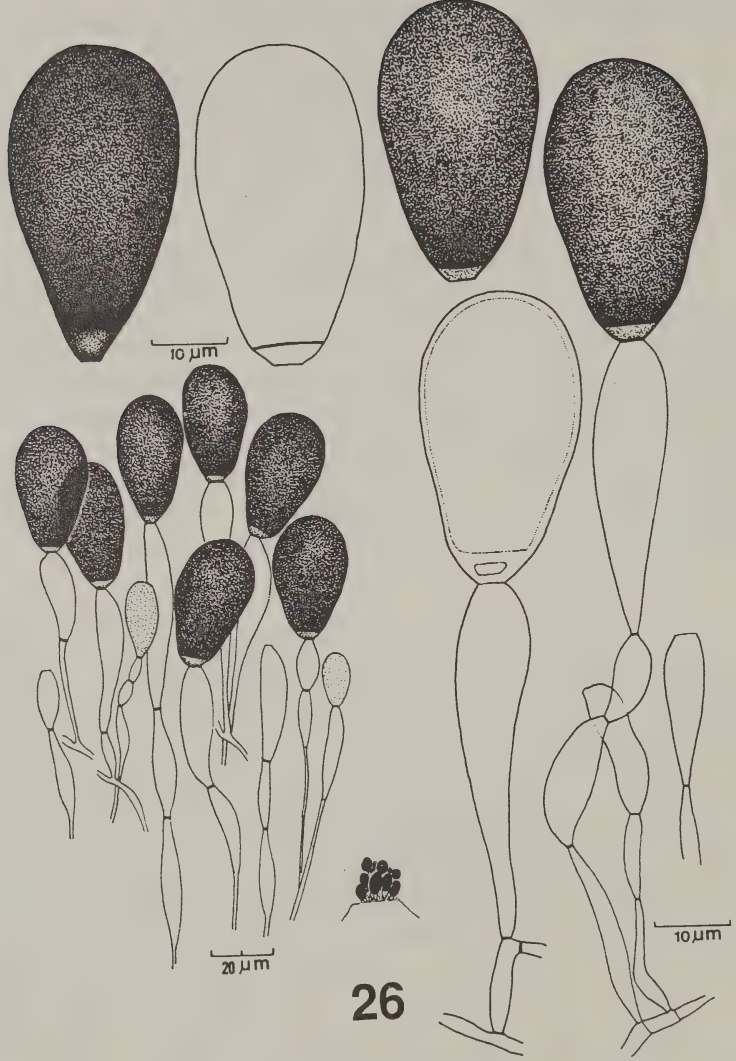


Fig. 26. *Vanakripa gigaspora* anam.-sp. nov.: sporodochial conidioma (habit sketch), inflated conidiogenous cells, and dark, obpyriform, didymosporous conidia.

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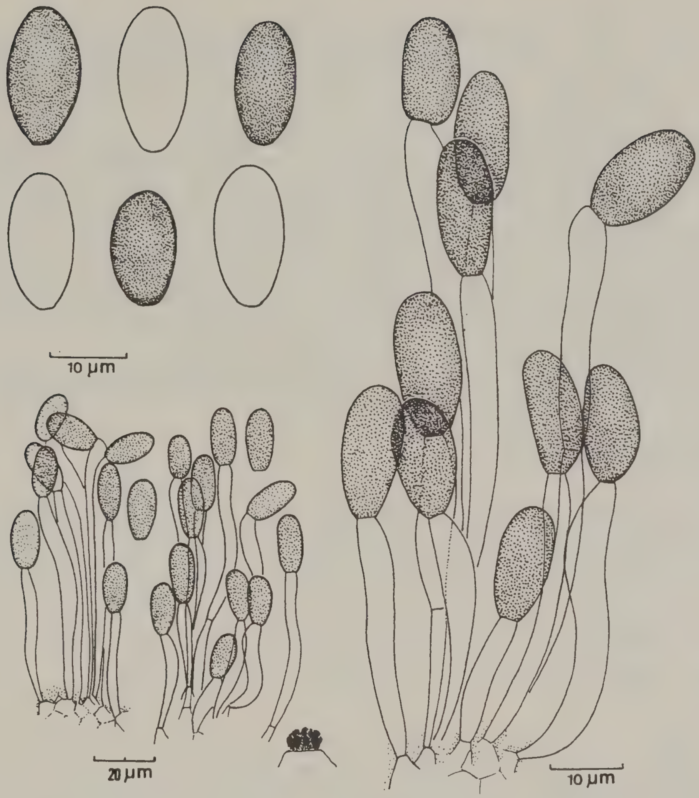

Fig. 27. *Vanakripa parva* anam.-sp. nov.: sporodochial conidioma (habit sketch), conidiogenous cells, and dark, amerosporous conidia.

ex hyphis septatis, ramosis, incoloratis, tenuitunicatis, laevibus, 2.5-4.5 µm lat. Conidiophora discreta, erecta, flexuosa, incolorata, 30-75 X 4-5 µm, septata, ramosa, laevia, spisse et paene parallela et in denso sporodochio 200-400 X 170-200 µm disposita; ex stromati pseudoparenchymatico enascentia. Cellulae conidiogenae vermiformes, curvatae, incoloratae, 18-40 X 3-5.5 µm, utrinque angustatae ad 2-3 µm lat., apice post secessionem conidiorum truncatae. Conidia ovata vel fusiformia, rotundata ad apicem, truncata ad basim, 7.5-10.5 X 4-6 µm, fuscantia, laevia, crassitunicata, non-septata.

Conidial fungi, hyphomycetes. Colonies effuse, black, velvety, corticolous. Mycelium partly immersed, partly superficial, composed of septate, branched, colourless, thin-walled, smooth hyphae 2.5-4.5 µm wide. Conidiophores differentiated, erect, flexuous, colourless, 30-75 X 4-5 µm, septate, branched, smooth, arranged compactly and almost parallel in sporodochia (200-400 X 170-200 µm) arising from a pseudoparenchymatous stroma. Conidiogenous cells holoblastic, vermiform, curved, colourless, 18-40 X 3-5.5 µm, narrower (2-3 µm wide) at the base and apex, truncate at the tip after conidium secession. Conidia ovoid to fusiform, rounded at the tip, truncate at the base, 7.5-10.5 X 4-6 µm, dark-coloured, smooth, thick-walled, non-septate.
HOLOTYPE: on dead twigs, Cotigao Wildlife Sanctuary, Goa State, India, 28 July 1991, D.J. Bhat, DAOM 214617.
Teleomorph: unknown.

*Vanakripa parva* differs from the type species of the genus *Vanakripa*, *V. gigaspora* Bhat, Kendrick & Nag Raj, by the absence of refractile septa in the conidiogenous hyphae, and in the smaller, non-septate conidia.

***Xenoheteroconium*** Bhat, Kendrick & Nag Raj **anam.-gen. nov.**
(Etym. Greek: *xeno* = foreign, different + *Heteroconium*).

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, brunneae, velutinae, hypophyllae. Conidiophora mononematica, discreta, non-ramosa, septata, erecta, recta, basi inflata et lobata, parte inferiore pallide brunnea, parte superiore fertili, atro-brunnea, saepe postea secedenti et velut propagulo. Cellulae conidiogenae apicales et intercalares, in conidiophoris et in conidiis integratae, monoblasticae, brunneae. Conidia phragmospora, euseptata, cylindrico-fusiformia, brunnea, sicca, laevia, saepe lateraliter e locis angustatis et protrudentibus, admodum subter septis et in conidiophoris et in conidiis aliis dispositis, interdum apicaliter in conidiophoris et conidiis exorientia.

Conidial fungi, hyphomycetes. Colonies effuse, brown, velvety, hypophyllous. Conidiophores mononematous, discrete, unbranched, septate, upright, erect, with expanded and lobed base, lower part mid brown, upper fertile part darker brown and often seceding later, presumably acting as a propagule. Conidiogenous cells apical and intercalary in the conidiophore and in conidia, integrated, monoblastic, brown. Conidia phragmosporous, euseptate, cylindric-fusiform, brown, dry, smooth-walled, usually arising laterally from narrow protruding loci just below septa both on the conidiophore and on other conidia, or

sometimes apically on conidiophores and conidia.
Type species: *Xenoheteroconium bicolor.*

Genera such as *Heteroconium* Petrak (1949), *Lylea* Morgan-Jones (1975), and *Septonema* Corda (1837), may be compared to *Xenoheteroconium. Heteroconium* produces conidia like those of *Xenoheteroconium*, but only in unbranched, acropetal chains (Ellis, 1971, 1976; Morgan-Jones, 1976). Mycelium in *Heteroconium* is also superficial on living leaves and sometimes associated with other fungi such as *Meliola* spp. and *Asterina* spp. (Morgan-Jones, 1976). Development in *Septonema* is similar to that in *Xenoheteroconium*, though conidia are more symmetrical and often in long, acropetal chains, and new conidia arising from extant conidia develop only from the apical cells of those conidia. The pattern of conidium formation in *Lylea* is more like that in *Xenoheteroconium*, but *Lylea* has short, inconspicuous conidiophores, symmetrical, cylindrical conidia with rounded ends, and the conidia are distoseptate, with extremely thick walls (Morgan-Jones, 1975). Of the four genera under discussion, only *Xenoheteroconium* has a parti-coloured conidiophore, with the darker apical portion seceding and acting as a propagule.

***Xenoheteroconium bicolor*** Bhat, Kendrick & Nag Raj **anam.-sp. nov.**
(Fig. 28)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, brunneae, velutinae, hypophyllae. Conidiophora mononematica, erecta, recta vel flexuosa, cylindrica, laevia, non-ramosa, infra pallide brunnea, supra brunnea (quod crassitudo parietis diversa hos duos colores efficit), 70-145 µm alt., 4-5.6 µm lat. in medio et superne, basi 5-7-lobata inflata usque ad 10-15 µm lat., 5-17-septata, septis 8-15 µm distantibus, ex extremis fractis percurrenter prolificantia. Cellulae conidiogenae terminales et intercalares in axe conidiophororum et in conidiis integratae, brunneae, monoblasticae; si terminales, versus apicem fertilem angustatae, si intercalares cylindricae vel utrinque leniter constrictae, protuberatione brevi, fertili, admodum subter septo distali exorienti praeditae; 8-14 X 3.5-4 µm. Conidia phragmospora, brunnea, laevia, sicca, duarum formarum: (1) conidia primaria breviora e cellulis stipitis et e conidiis aliis oriunda, 20-42 X 3.5-5 µm, fusiformia vel obclavata, recta, prope basim rotundatam vel truncatam latissima, sursum gradatim angustata ad apicem anguste rotundatum vel acutum, 2-4-euseptata, plerumque 3-septata, ad septa leniter constricta, modice crassitunicata, facile secedentia; (2) conidia secunda longiora, quae partes fuscantes et fertiles sunt conidiophororum, 53-77 X 4.5-5.5 µm, recta vel leniter curvata, cylindrica vel cylindrico-fusiformia, ad basim truncata, versus apicem attenuata, 4-7-euseptata, ad septa leniter constricta, modice crassitunicata, serotine secedentia.

Conidial fungi, hyphomycetes. Colonies effuse, brown, velvety, hypophyllous. Conidiophores mononematous, erect, straight or flexuous, cylindrical, smooth-walled, unbranched, lower part pale brown, upper part brown, with a sharp line of demarcation between the two levels of pigment (the two colour zones a direct result of different wall thickness), 70-145 µm tall, 4-5.6 µm wide in the middle and above, broadening to 10-15 µm wide at the 5-7-lobed base; 5-17-septate, septa 8-15 µm apart; regenerating percurrently from broken ends. Conidiogenous cells terminal and intercalary in the upper part of the conidiophore axis and in primary conidia, integrated, monoblastic, brown; if terminal, tapered toward the fertile apex, if intercalary, cylindrical or slightly constricted at each end, cylindrical or slightly constricted at each end, with a small fertile protuberance just below the distal septum; 8-14 X 3.5-4 µm. Conidia phragmosporous, brown, smooth, dry, of two types: (1) shorter primary conidia arising from cells of the stipe and from other primary conidia, 20-42 X 3.5-5 µm, fusiform to obclavate, straight, widest near the rounded or truncate base, tapering gradually toward the narrowly rounded or pointed apex, 2-4-euseptate, usually 3-septate, slightly constricted at the septa, moderately thick-walled, seceding readily; (2) longer secondary conidia (the more darkly pigmented, fertile upper portions of conidiophores), 53-77 X 4.5-5.5 µm, straight to slightly curved, cylindrical to cylindric-fusiform, truncate at the base, tapering toward the tip, 4-7-euseptate, often slightly constricted at the septa, moderately thick-walled, seceding late.
HOLOTYPE: on decaying leaves, Agumbe, Karnataka State, India, 12 Nov. 1989, D.J. Bhat, DAOM 214618. Additional material examined: on decaying leaves, Agumbe, Karnataka State, India, 12 Sept. 1989, D.J. Bhat, DAOM 214621.
Teleomorph: unknown.

*Xenoheteroconium bicolor* produces two kinds of propagule which, although functionally identical, are clearly distinguishable by their modes of development and dehiscence, and by their sizes. It is interesting, and perhaps significant, that the more numerous 'conventional' primary conidia mostly arise singly from small, solitary swellings on the side of, and just below the distal septum of, the cells of the upper part of the conidiophore or of other conidia, and have a narrow base; some are borne apically, but in both cases, they are clearly blastic. The atypical

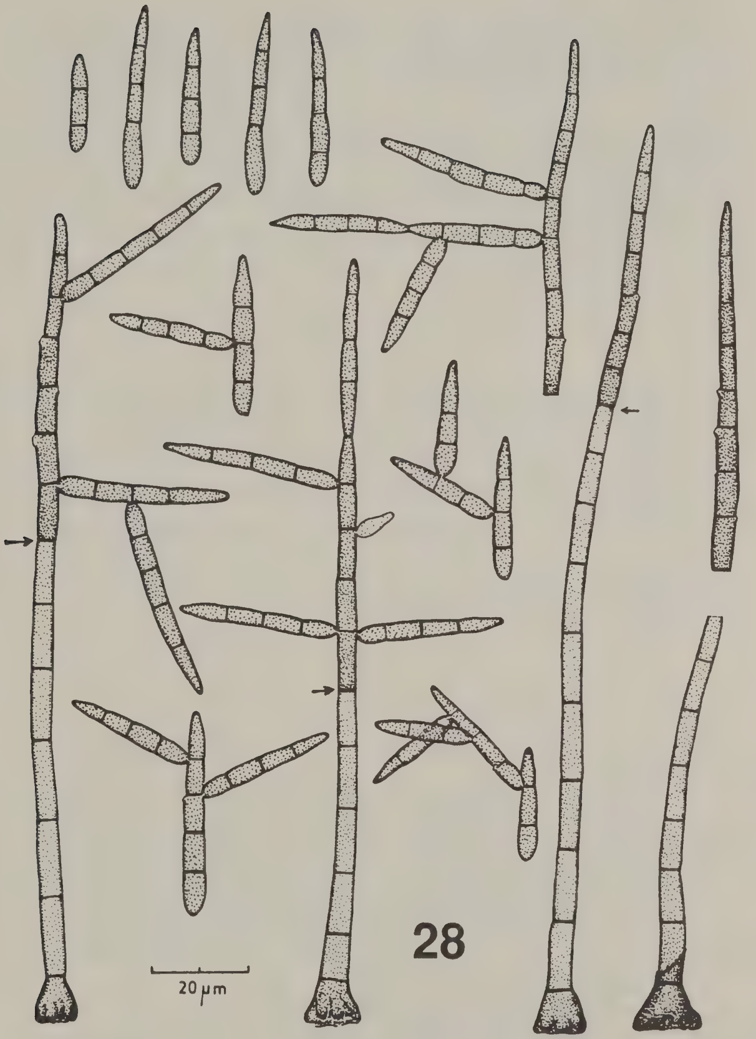

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Fig. 28. *Xenoheteroconium bicolor* anam.-sp. nov.: conidiophores, primary conidia in branched chains, and secondary conidia (bases indicated by arrows).

secondary propagules represent a conversion of, and a secondary function for, the upper portion of the conidiophore. These propagules are far fewer in number than the others, as well as longer and with more septa, but the most striking difference lies at their base, which has what Kendrick *et al.* (1971) called a "full-width connection" to the lower part of the conidiophore. This and their earlier role as the fertile part of the conidiophore indicates that these conidia are thallic, and establishes a clear, as well as conceptually interesting, developmental dichotomy between the two kinds of spores produced by *Xenoheteroconium.*

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# SYSTEMATIC AND BIOLOGICAL STUDIES IN THE BALANSIEAE AND RELATED ANAMORPHS. V. THE EPHELIS ANAMORPH OF BALANSIA ARISTIDAE

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## ABSTRACT

A review is made of the nomenclatural history of *Balansia aristidae* (Atk.) Diehl and of its known host range and geographical distribution. A brief account of the history of the genus *Ephelis* is also presented. Morphological characteristics of the *Ephelis* conidiomata of the Balansieae and particulars of conidiogenesis are noted. The development and morphology of the *Ephelis* anamorph of *B. aristidae* on *Aristida purpurascens* Poir. are described. Details of hyphal egress and primary stroma formation and conidiomatal structure are included. A formal taxonomic description of the anamorph is provided.

## INTRODUCTION

The fungus presently classified as *Balansia aristidae* was originally named *Dothichloe aristidae* Atk., and described from a collection made on *Aristida purpurascens* Poir. in Auburn, Alabama (Atkinson, 1894). Two species, *Dothichloe hypoxylon* (Peck) Atk. [≡ *Epichloe hypoxylon* Peck] and *D. aristidae*, were included in the genus *Dothichloe* Atk. when it was first established (Atkinson, loc. cit.). In erecting the genus it was thought that these species differed from fungi classified in *Epichloe* (Fr.) Tul. and *Hypocrella* Sacc. by possessing dothidiaceous rather than hypocreaceous stromata, a distinction no longer considered valid. Unfortunately, the name *Dothichloe hypoxylon* was used erroneously by Atkinson, based on a misidentification. The fungus to which he applied the name was evidently *Balansia henningsiana* (Möell.) Diehl. The description under the name *D. hypoxylon*, which he considered to typify his new genus, was based on material of *B. henningsiana* occurring on the abaxial surface of leaves of *Andropogon virginicus* L. in Alabama. This was a rather surprising error, since Atkinson states that the material agreed well with what he referred to as authentic specimens of Peck's species. Added to that is the fact that *D. hypoxylon* proper [now, paradoxically,

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classified as *Atkinsonella hypoxylon* (Peck) Diehl; the type species of *Atkinsonella* Diehl] is an epiphyte on grass inflorescences and does not form stromata on leaves. Atkinson further stated that he believed *Hypocrea atramentosa* Berk. & Curt. to be probably a synonym of what he called *Dothichloe hypoxylon*. Quite clearly, a number of taxa were being badly confused and the differences between them were not realized. Because of Atkinson's error, Diehl (1950) selected *Balansia aristidae* as the lectotype species of *Dothichloe*, thereby making the generic name a synonym of *Balansia* Speg. The genus *Hypocrella* Sacc. is now classified in the subfamily Oomycetoideae of the Clavicipitaceae (Diehl, 1950). It had four original species (Saccardo, 1878); *H. discoidea* (Berk. & Br.) Sacc., *H. bambusae* (Berk. & Br.) Sacc., *H. atramentosa* (Berk. & Curt.) Sacc., and *H. semiamplexa* (Berk.) Sacc. *H. atramentosa*, a member of the Balansieae, is currently known as *Myriogenospora atramentosa* (Berk. & Curt.) Diehl, the fungus that Atkinson (loc. cit.) thought to be the same as *B. henningsiana* [as *D. hypoxylon*].

As with many other taxa in the genus *Balansia* there has, historically, also been some confusion concerning the identity of *B. aristidae*. Tracy and Earle (1895) referred to a collection of it on *Aristida stricta* Michx. from Mississippi as *Hypocrella hypoxylon* (Peck) Sacc., now, as noted above, classified as *Atkinsonella hypoxylon*. The latter is a very different fungus, host-specific to species of *Danthonia* DC., including *D. compressa* Aust., *D. sericea* Nutt., and *D. spicata* (L.) P. Beauv. (Leuchtmann and Clay, 1989). Stevens (1917) used the name *Dothichloe aristidae* for two collections of *Balansia subnodosa* Atk. on *Ichnanthus pallens* Munro in Puerto Rico. Chardon (1920) established the name *Dothichloe subnodosa* Chardon as a new species, deriving the specific epithet from an unpublished manuscript containing the binomial *Balansia subnodosa* authored by G. F. Atkinson. Diehl (1950) took up the name *Balansia subnodosa* Atk. apud Chardon, which was published as a synonym of *D. subnodosa* by Chardon (loc. cit.). Chardon also listed *Dothichloe nigricans* (Speg.) Seaver as an additional synonym. Its basionym, *Epichloe nigricans* Speg., is, however, a synonym of *Balansia strangulans*. Another misuse of the name *B. aristidae* occurred when Diehl (1930) employed it to refer to the *Ephelis* anamorph of *Balansia strangulans* (Mont.) Diehl. The name *Ophiodothis aristidae* Atk. appeared for *B. aristidae* in Saccardo (1896) and subsequently Earle (1900) classified it as a variety of *Ophiodothis atramentosa* (Berk. & Curt.) Earle (≡ *Myriogenospora atramentosa*). The latter author listed *Epichloe hypoxylon* [≡ *Atkinsonella hypoxylon*] among its synonyms, again indicating that the species concepts continued to be poorly defined and misunderstood.

*Balansia aristidae* is known to occur on a least ten species of *Aristida* L., a genus of the Poaceae. It causes a so-called black-choke disease. As indicated above, its type collection was made on *A. purpurascens* in Alabama. It has also been encountered in that state on *A. dichotoma* Michx. and *A. longespica* Poir. and on *A. adscencionis* L. [as *A. oligantha* Michx.] in Mississippi (Diehl, 1950). The fungus was reported from Florida by Earle (1900), where it has been collected on *A. longespica*, *A. spiciformis* Elliott and *A. stricta* (Diehl, 1950). Stevens (1917), Stevenson (1918) and Chardon (1920) reported it on *A. portoricensis* Pilger in Puerto Rico and there is a record of its occurrence on

*A. setifolia* H.B. & K. in Brazil (Sydow, 1916). In addition Diehl (1950) lists specimens from Cuba, the Dominican Republic, and Venezuela on *A. vilfifolia* Henr., *A. refracta* Griseb., and *A. adscencionis*, respectively. It seems likely that it is widely distributed in the southeastern United States, the Caribbean, and South America.

The generic name *Ephelis* Fr. was first proposed by Fries (1849), without a species citation. Subsequently, Berkeley (1869) described *Ephelis mexicana* Fr., based on a collection provided by E. M. Fries. This is a binomial of uncertain application because it cannot be satisfactorily typified (Diehl, 1950). The treatment of it by Berkeley (1869) was based on two collections, probably on different, but undetermined, hosts and of different geographical origin. Diehl (1950) thought that it could be the anamorph of *Balansia obtecta* Diehl but there is a possibility that it could be that of *B. claviceps* Speg. It seems most likely to have been based on the anamorph of the former. Ellis and Everhart (1886) and Cooke and Massee (1889) were the first to document *Ephelis* as the anamorph of *Balansia*. The former reported *Ephelis borealis* Ell. & Everh. as a stage of *Balansia hypoxylon* (Peck) Atk. [≡ *Atkinsonella hypoxylon*], while the latter described *B. trinitensis* Cke. & Massee and *Ephelis trinitensis* Cke. & Massee from a collection on *Setaria palmifolia* Willd. made in Trinidad. *Balansia trinitensis* is now considered a later name for *Balansia claviceps* Speg. (Spegazzini, 1885), the type species of *Balansia* (Diehl, 1950). The binomial *Ephelis texensis* Ell. & Everh. was used by J. B. Ellis as a herbarium name for the anamorph of *Balansia cyperi* Edg., but was not published (Diehl, 1950). Various other authors have, over the years, studied *Ephelis* anamorphs of *Balansia* species and some whose teleomorphs are unknown. Atkinson (1905), Edgerton (1919), Weber (1924) and Diehl (1930; 1950) each made contributions to knowledge in this area. In addition to those described from the Americas, *Ephelis japonica* P. Henn. is known from Japan and *E. oryzae* Syd., from India. The former, described from Japanese specimens on *Miscanthus tinctoria* Hack. and *Paspalum thunbergii* H. B. & K. (Hennings, 1904), is superficially similar to *B. obtecta* (Diehl, 1950). The latter was described by Sydow (1914) on rice (*Oryza sativa* L.) from southern India. It is uncertain if these taxa are different from *B. obtecta* and from each other. Diehl (1950) noted that *E. japonica* differs in having a thin, gray-colored primary stroma enveloping the inflorescenses of its hosts, in contrast to the black, shining stroma of *B. obtecta*. In this regard, *E. japonica* resembles *E. oryzae*. These differences may be merely a reflection of host association or maturity and a reevaluation of the validity of these names is needed.

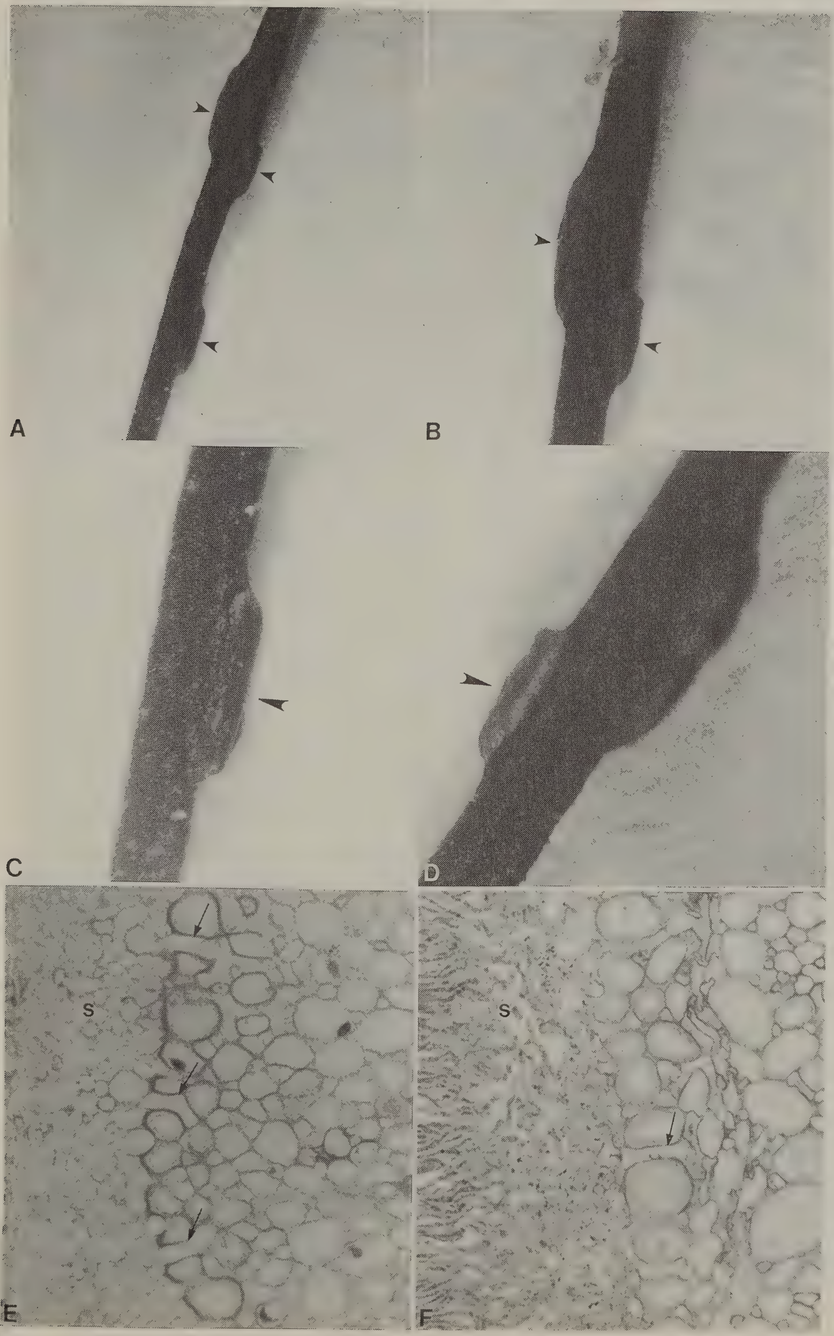
*Ephelis* anamorphs have been encountered on a wide range of grasses and cereals in India. Venkatakrishnaiya (1946) tentatively identified *E. oryzae* on *Eragrostis tenuifolia* Hochst. and *Isachne elegans* Dalz. He later added (Venkatakrishnaiya, 1952) two other cereals, *Setaria italica* Beauv. and *Echinochloa crus-galli* Beauv., as hosts of this fungus. Patel *et al.* (1951) reported what they believed to be the *Ephelis* anamorph of *Balansia andropogonis* Syd. inducing spikelet sterility in a species of *Aristida*. Govindu and Thirumalachar (1954, 1960), and Govinda Rao *et al.* (1959) documented the occurrence of *Ephelis* on over twenty other grasses. Some of their collections were identified as being *E. oryzae*.

The morphology of the *Ephelis* conidiomata of the Balansieae has been variously interpreted. Diehl (1950) referred to some as being pycnidial whereas Ullasa (1969) considered the anamorph of *Balansia claviceps* to be a modified sporodochium. Differences in conidiomata, as well as ascostromata, prompted Diehl (1950) to recognize two subgenera of *Balansia*, namely *Eubalansia* and *Dothichloe*. In the former, the *Ephelis* anamorph was said to be patellate to cupulate with a well-defined peridium whereas the latter was characterized by possession of effuse to hysteriform conidiomata. Rykard *et al.* (1982) described the anamorph of *Myriogenospora atramentosa*, noting it to be identical to the genus *Ephelis* and thus confirming the validity of the classification of that species in the Balansieae (Luttrell and Bacon, 1977). Conidiomata were described as being irregularly hysteriform acervuloid to pycnidial in form, becoming more acervuloid at maturity. They were reported to be surrounded by a dark layer of irregular hyphae in a peridium-like manner. Conidiophores were found to be simple, sympodial and to produce conidia holoblastically. Studies on the *Ephelis* anamorphs of *Atkinsonella hypoxylon*, *Balansia epichloe* (Weese) Diehl, *B. henningsiana*, *B. strangulans* and *Balansiopsis pilulaeformis* (Berk. & Curt.) Diehl were reported by Rykard *et al.* (1984). Differences in conidiomatal morphology among them were documented. *Balansia strangulans* was found to produce an effuse, continuous palisade of conidiophores over the even surface of a primary stroma encircling the host culm and covered by an evanescent peridial layer. In *B. epichloe* and *B. henningsiana*, conidiophores are formed in flat, hysteriform cavities separated by sterile ridges. Conidiophores of *B. pilulaeformis* were reported to be localized, occurring in small discoid cavities in the stroma. Both *Atkinsonella hypoxylon* and *B. claviceps* form apothecioid conidiomata originating as protuberances from the primary stromata. An account of the *Ephelis* states of *A. hypoxylon* and the closely related *A. texensis* (Diehl) Leuchtmann & Clay was given by Leuchtmann and Clay (1988) and Morgan-Jones and White (1989). The ontogeny and morphology of the *Ephelis* anamorph of *Balansia aristidae* are reported upon herein.

## MATERIALS AND METHODS

Test plants of *Aristida purpurascens* infected with *Balansia aristidae* used during these studies were transplanted from a site in Montgomery County, Alabama, and maintained in pots in a greenhouse as described by Phelps *et al.* (1993). Culm segments bearing ephelidial stromata at various stages of development were harvested at appropriate times and prepared for sectioning. Fixation, dehydration, infiltration, sectioning, and staining procedures were performed as described by Phelps *et al.* (loc. cit.). For purposes of conidiophore and conidium observation, squash mounts of the fertile conidiomatal hymenium were examined by phase-contrast microscopy. Sizes represent averages of forty measurements.

PLATE 1. *Ephelis* stroma of *Balansia aristidae* on *Aristida purpurascens*. A-D, pustular conidiomata (indicated by arrowheads) on surfaces of culm-borne stromata [A, X 6; B, X 10; C, X 14; D, X 16]; E & F, portions of culm cross sections showing hyphal bridges (indicated by arrows) inbetween epidermal cells [s, stroma] [X 1000].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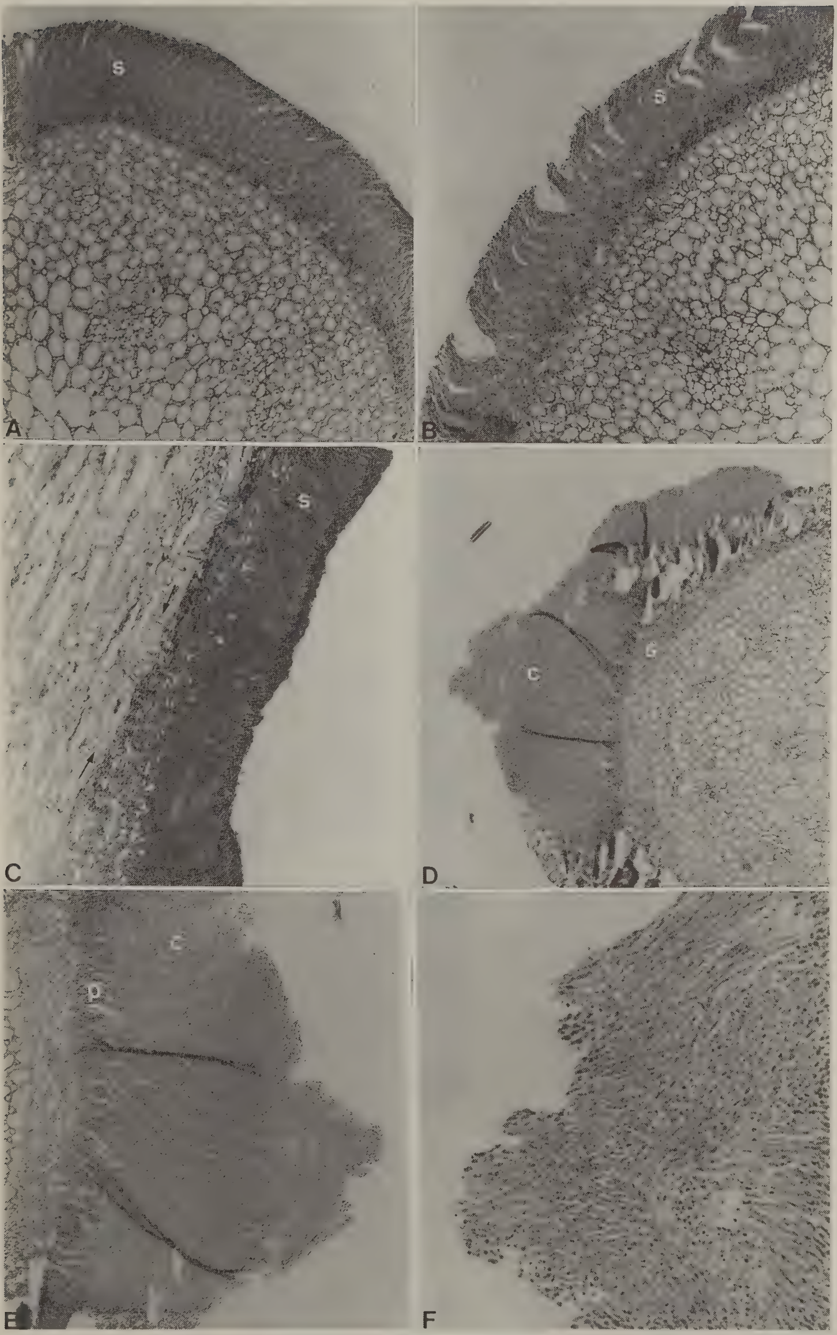
# RESULTS

## PRIMARY STROMA DEVELOPMENT

As described previously (Phelps *et al.*, 1993) hyphae of *Balansia aristidae* grow systemically in intercellular spaces of culm tissues prior to egress to form superficial conidial and perithecial stromata on the host plant surface. Progressive build-up of fungal hyphae occurs. At the time of primary stroma initiation they are abundant throughout the culm, even within and around vascular bundles, but are especially concentrated subepidermally often in an anthocyanescent region extending 1 to 3 cm immediately below a node. Egress begins at the top of this zone, progressing from the node downward. The entire region typically remains concealed by the subtending leaf during the initial stages of stroma development. At first, a few hyphae growing subepidermally emerge from the culm in a wedge-like fashion inbetween epidermal cells and grow superficially in a prostrate manner, closely appressed to the culm surface. These give rise initially to a thin, densely woven, epiphytic hyphal network, which spreads 1 to 2.5 cm down the culm. As the epiphytic mycelium increases and assumes a felt-like, loosely prosenchymatous texture, hyphal bridges between it and the endophytic fungal biomass increase in number with concurrent further proliferation subepidermally (Plate 1, E & F). Sclerotization of the newly formed superficial mycelium, and melanization of its constituent hyphae near its surface, begin soon after the emergence, leading to the formation of a primary stroma. Stromal maturation, like egress, follows a basipetal progression. Hyphal elements, through abundant branching, eventually become tightly packed forming a smooth, dense, felt-like prosenchymatous layer (Plate 1, E). Concurrent thickening and pigmentation of hyphal cell walls is reflected in progressive color change from pale yellowish brown to orange-brown. As stroma maturation proceeds, hyphae accumulate inbetween the epidermis and subtending parenchyma growing more or less laterally, peripherally, parallel to the epidermal layer and disassociating it from the tissue below (Plate 1, F). A substantial mat of hyphae eventually develops below the epidermis, particularly proximal to the regions where the *Ephelis* conidiomata are formed (Plate 3, C-E). Hyphae in the central portion of the culm continue to grow predominantly vertically. At maturity the primary stroma is prosenchymatous to pseudoparenchymatous in texture (Plate 1, E; Plate 3, F) and its surface is dark brown to black (Plate 1, A-D; Figure 1, B). The subtending leaf blade normally falls away from the culm prior to this stage, although rarely it remains stuck to the mature conidial stroma.

PLATE 2. Portions of thin sections showing the primary stroma and *Ephelis* anamorph of *Balansia aristidae* on *Aristida purpurascens*. A & B, culm borne primary stromata (s) in cross section [X 400]; C, culm-borne primary stroma (s) in longitudinal section [X 400]; D-F, pustular conidioma in cross section showing agglutinous mass of conidia (c) [p, conidiophore palisade; (s) stroma] [D, X 200; E, X 400; F, X 1000].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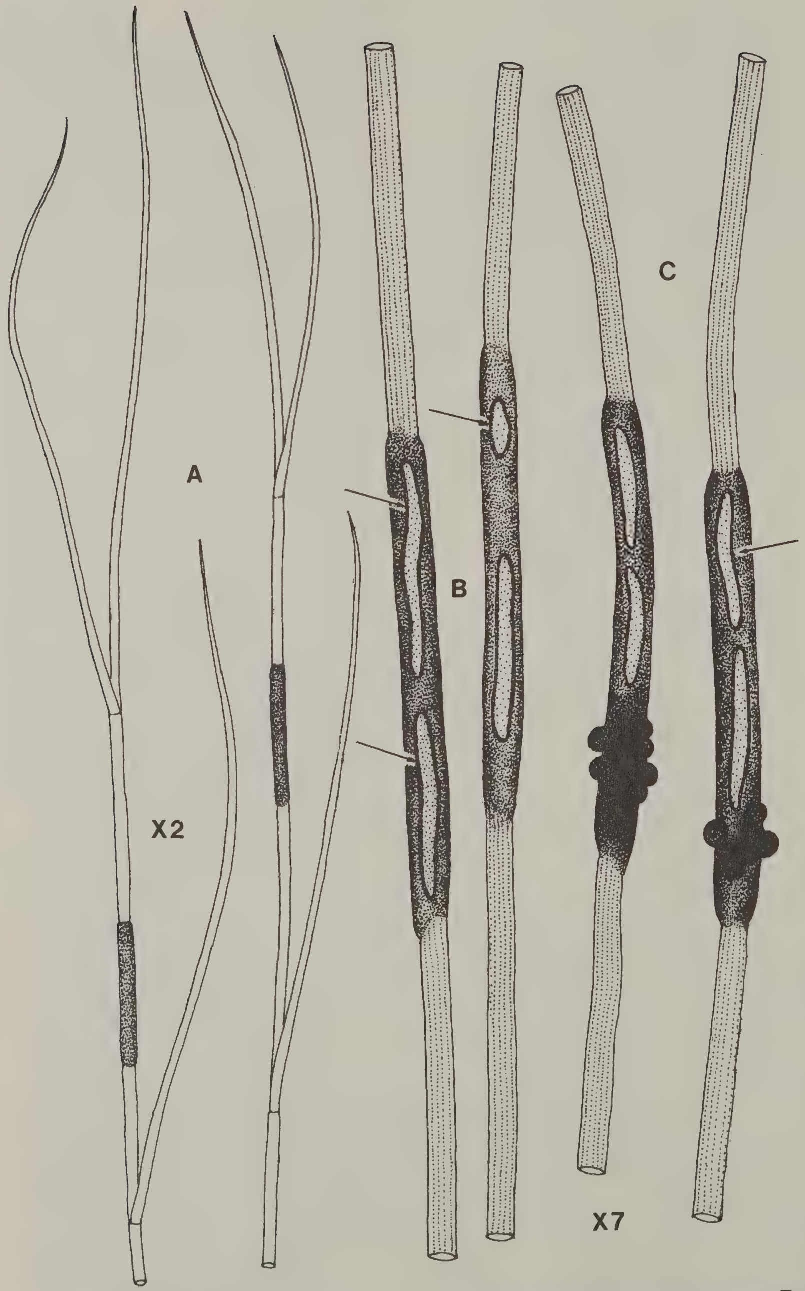


FIGURE 1. *Balansia aristidae*. A, primary stromata on culms; B, *Ephelis* conidiomata (indicated by arrows); C, conidiomata and perithecia.

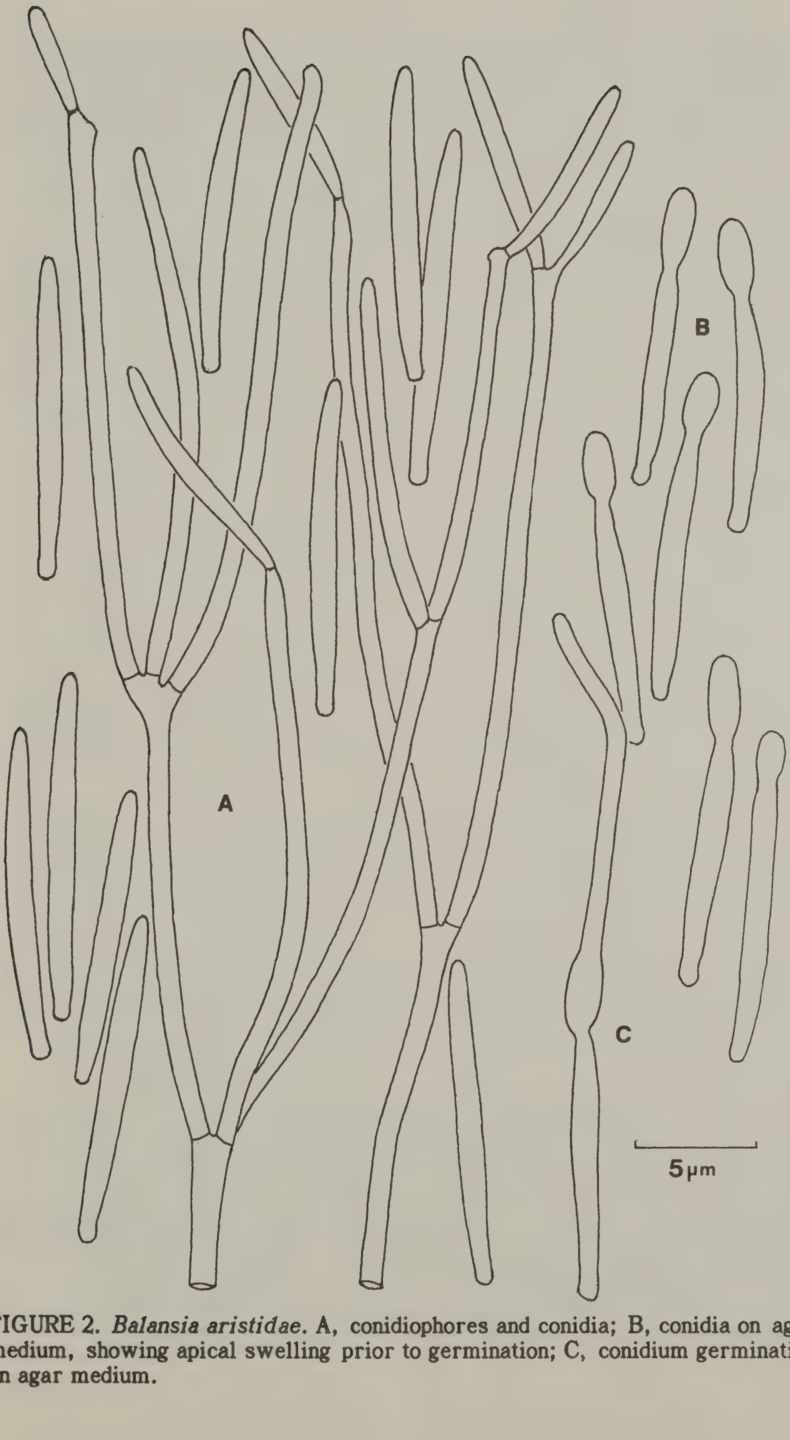


FIGURE 2. *Balansia aristidae*. A, conidiophores and conidia; B, conidia on agar medium, showing apical swelling prior to germination; C, conidium germinating on agar medium.

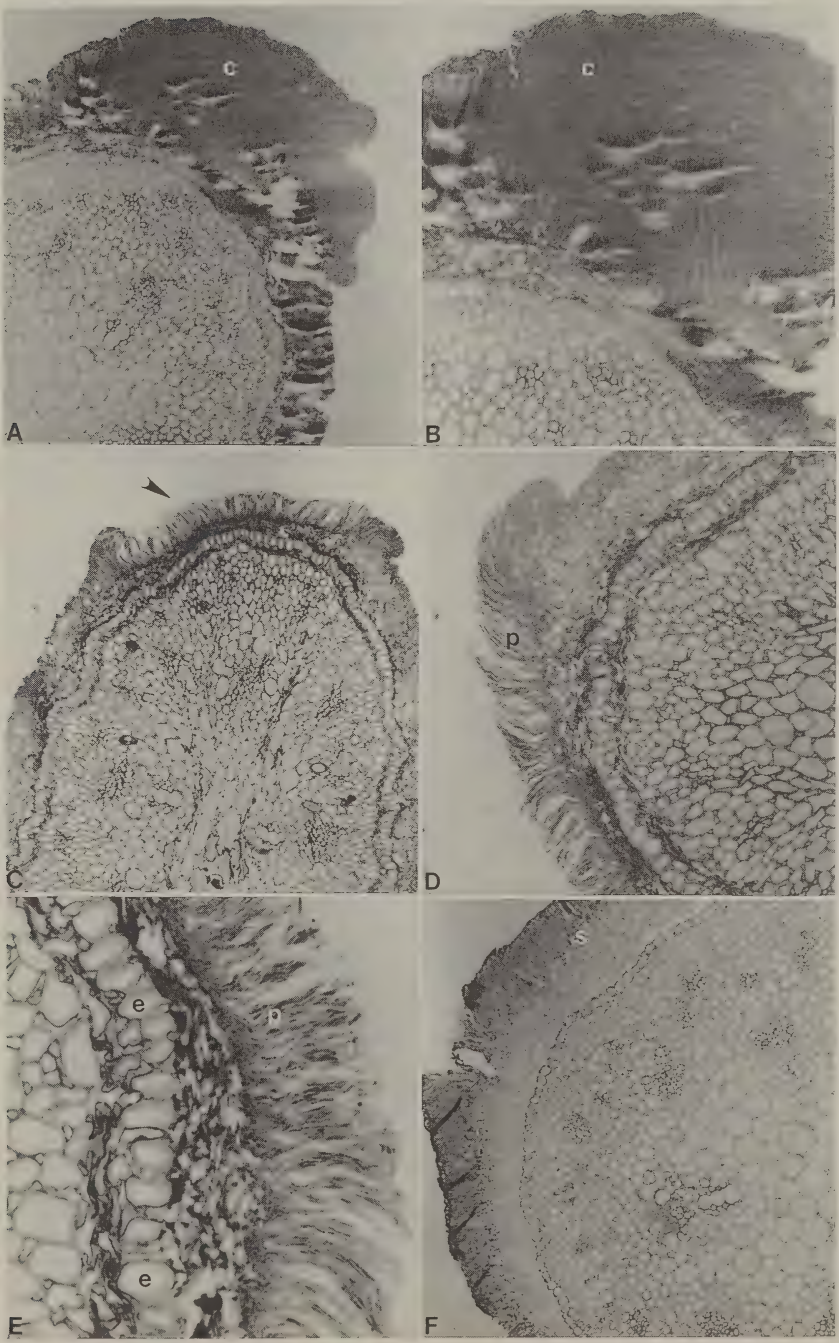
Conidiomata of *B. aristidae* develop within the primary stroma as it matures. Initially, localized groups of conidiophores begin to differentiate from loosely packed hyphal branches a short distance below the surface of the very young epiphytic mycelial mat. Conidiophores become progressively more numerous, branching verticillately as they mature (Figure 2, A), and forming dense, well-defined palisades (Plate 3, C-F). Subtle but distinct outlines of these primordial ephelidial fructifications frequently appear with the first visible pigment. Individual fertile areas are separated by sterile stromatic tissue. Conidiation commences very early during conidiomatal development, but remains light until later stages. Although the sterile mycelium does grow over developing palisades, overlying layers are thin relative to the surrounding mycelial matrix, which becomes deeper and thicker, conferring a slightly sunken or concave aspect to conidiomata. Ongoing maturation and stretching of the stromal surface, including those areas overlying palisades, is accompanied by substantial increases in conidiation. As large volumes of agglutinous conidia are produced, the surrounding mycelial matrix is compressed, forming locules. Continued conidiation forces the overlying prosenchyma to swell, creating a convex, pustular appearance (Plate 1, A-D). Pustules are amber to olive brown in color, slightly translucent, and ellipsoid to oblong, or boat-shaped, with occasional extremes being either round or hysteriform and running the full stromal length. Further linear growth of verticillately branched conidiophores and profuse conidiation cause the pustule to break open. Its surface splits linearly down the center and retracts from the bulging conidial mass (Plate 2, D-F; Plate 3, A & B), forming a slightly raised border or somewhat irregular ridge around the fertile region (Plate 3, C & D), giving the conidioma a long, cleft, hysteriform aspect when viewed from above (Figure 1, B). Exposed conidia quickly disperse in water, but under dry conditions may remain undisturbed in their agglutinous condition for days, eventually drying out. In mass the conidia appear yellowish to olive. Following dispersal or dehydration of the conidial mass, the former pustule resembles a crater-like depression in the stroma surface (Plate 3, C).

## TAXONOMIC DESCRIPTION

*Ephelis* anamorph of *Balansia aristidae* (Atk.) Diehl, USDA *Agric. Monogr.* 4: 43, 1950.

Mycelium immersed in host tissue, hyaline, septate, smooth, branched 1.5-2 µm wide. Primary stromata effuse, prosenchymatous to pseudoparenchymatous, superficial, encircling host culms, up to 30 µm thick and 22 mm in length, yellowish to orange brown when young, becoming dark brown

PLATE 3. Portions of thin sections showing the primary stroma and *Ephelis* anamorph of *Balansia aristidae* on *Aristida purpurascens*. A & B, cross section of pustular conidioma showing agglutinous conidial mass (c) [A, X 200; B, X 400]; C-E, cross section showing conidiomatal palisade (indicated by arrowhead) and subepidermal hyphal mat [e, host epidermis; p, palisade] [C, X 200; D, X 600; E, X 1000]; F, nonfertile region of mature *Ephelis* stroma (s) showing developing secondary stroma [X 300].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to black at maturity, at first dense and compact, later more loosely arranged, each stroma usually bearing several conidiogenous locules. Conidiomata eustromatic, ephemeral, at first covered (Plate 1, A-D), later becoming erumpent, opening in a hysteriform fashion by a linear, longitudinal fissure, typically boat-shaped or long-lenticular in surface view (Figure 1, B), unilocular, conidia oozing in olivaceous masses, when open bordered by a narrow dark ridge of laterally displaced stromatic tissue. Conidiophores micronematous, hyaline, smooth, septate, branched dichotomously or verticillately at one or more levels (Figure 2, A), arranged in dense fascicles, formed from hyphae lining the base of the conidiomata. Conidiogenous cells (Figure 2, A) filiform, straight or slightly flexuous, holoblastic, sympodial, indeterminate, giving rise to a sequence of a few conidia at the apex, 1-1.5 µm wide. Conidia hyaline, aseptate, acicular, obtuse at the apex, subtruncate at the base, straight, thin-walled, (9.5)-13-(15.5) x 1 µm (Figure 2, A).

On *Aristida* spp.; North, Central and South America.

Collection examined: on *Aristida purpurascens* Poir., Campus of Auburn University at Montgomery, Montgomery County, Alabama, May 1992, R.A Phelps and M.R. Owsley, AUA, BPI.

## DISCUSSION

The conidiomata of *Balansia aristidae* are closely similar to those of the anamorphs of other species of *Balansia*, and of *Atkinsonella hypoxylon* and *A. texensis*, in that a flat, more or less even, palisade of densely-packed conidiophores is produced in shallow cavities formed within developing primary stromata. Stromata of *Balansia* can be extensive and effuse or restricted and pulvinate, particularly when localized in host inflorescences as in *Balansia pallida* Wint. A plethora of different loculate, acervuloid to cupulate forms exists within the tribe and there is something of a continuum between them. However, recognition of the peculiarities of individual conidiomatal types may be a useful criterion in species characterization. The various conidiomata differ in overall morphology, particularly in shape. They are either linear and hysteriform or rounded and apothecoid. The extent of fertile areas, whether localized or covering most or all of the surface of the stroma, is another variable, as is the thickness and persistence of stromal tissue overlying the conidiophore palisade. In some taxa, such as *Atkinsonella hypoxylon*, where conidiomata are apothecoid, the tissue at the margin of the fertile area is excipular in form. In others, possessing effuse fertile areas, such as *Balansia henningsiana*, irregular clusters of conidiophores are separated only by flat, sterile areas of the stroma and often coalesce at maturity. Stromal tissue covering the conidiophore palisade in species with effuse stromata tends to be thin and ruptures early and disappears, exposing masses of conidia. This is the case in *B. henningsiana* and *B. strangulans* (Rykard *et al*., 1984). *Balansia aristidae* appears to differ from the latter, to which it is closely similar in habit and overall morphology, in having more localized fertile conidiogenous areas. Both form black, collar-like stromata on their respective hosts and, according to Diehl (1950), differ only in *B. aristidae* possessing perithecia with prominent necks that protrude more distinctly from the ascostromata. Diehl noted the *Ephelis* anamorphs of *B. aristidae* and *B. strangulans* to be identical except for the former being less conspicuous and more ephemeral. Rykard *et al.*, (1984) reported *B. strangulans* on *Panicum hians* Ell. to form palisades of conidiophores on young stromata in poorly defined patches, covered by a thin layer of stroma which quickly disappears. Eventually the fertile area extends in a continuous layer covering the entire surface of the stroma encircling the culm. This is different from *B. aristidae* and confirms the validity of the separation of these two taxa.

The two subgenera of *Balansia*, *Eubalansia* and *Dothichloe*, established by Diehl (1950) on the basis of conidiomatal morphology and ascostromatal differences, are not considered to be useful or necessary taxonomic entities (Morgan-Jones *et al.*, 1992). The distinction between them is not, in all instances, clear-cut, for there is similar variation in ascostromal characteristics, from effuse to pulvinate to capitate, as there is in conidiomata. *Balansia* is a relatively small genus, containing less than twenty species, and its division into two subgenera seems superfluous.

The phenomenon of external anamorph stromal development on a host surface, supported by endophytic mycelium through hyphal bridges, is known to occur in *Balansia epichloe* on leaves (Rykard *et al.*, 1985; White and Owens, 1992). The host-pathogen relationship in *Balansia aristidae* on *Aristida purpurascens* is similar, except that the stromata are formed on culms. *Balansia strangulans* and *B. subnodosa* have, presumably, the same type association with their hosts, although the latter forms a restricted, pulvinate stroma surrounding the culm of its hosts. The precise nature of the host-fungus relationship in some other species, such as *B. ambiens* Möell., which forms a linear, blackish primary stroma bearing a hysteriform *Ephelis* anamorph on culms and inflorescences (Diehl, 1950), remains unknown.

## ACKNOWLEDGEMENTS

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# SYSTEMATIC AND BIOLOGICAL STUDIES IN THE BALANSIEAE AND RELATED ANAMORPHS. VI. THE TELEOMORPH OF BALANSIA ARISTIDAE

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## ABSTRACT

A brief review of the morphology of ascostromata in the Balansieae is presented. Teleomorph development and morphology, including ascostroma and perithecia, of *Balansia aristidae* (Atk.) Diehl on *Aristida purpurascens* Poir. is described. Details of transition from primary anamorph stroma to secondary perithecial stroma are given. A taxonomic description of the teleomorph is provided.

## INTRODUCTION

Ascostromata of the Balansieae vary considerably in morphology, texture, pigmentation and the position at which they occur on the plant (Sampson, 1933; Diehl, 1950; Luttrell and Bacon, 1977; Leuchtmann and Clay, 1988; Morgan-Jones and White, 1989). Some form exclusively on culms, others on leaves, and a few are associated with the inflorescences of their hosts. In *Epichloe typhina* (Tul.) Fr. ascostromata are formed only on culms bearing inflorescence primordia (Sampson, loc. cit.; Kirby, 1961) and, when mature, surround both leaf sheaths and stems of their hosts. Initially, an effuse mass of white mycelium envelops the upper leaf sheath and becomes organized into a stroma which bears a loose palisade of aculeolate conidiogenous cells (White and Morgan-Jones, 1987). Following conidiation the stroma progressively thickens, and turns pale orange to buff in color as perithecia are formed (Sampson, loc. cit.; Doguet, 1960; White *et al.*, 1991, 1992). Perithecia develop on the surface of the primary stroma and possess discrete, distinct walls from which evanescent paraphyses arise (Webster, 1970). As they mature, they become enveloped by the secondary ascostroma. Ascostromata are more or less flat and even, encircling the culm and often extend to a length of several centimeters. Mature ascostromata of the other genera of the tribe, *Atkinsonella* Diehl, *Balansia* Speg., *Balansiopsis* Höhn, and *Myriogenospora* Atk. are generally

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black in color, although melanization is limited to the outermost cells. *Balansia pallida* Wint., which has yellowish ascostromata borne on florets of *Luziola peruviana* Gmel. (Diehl, 1950), is an exception. It is superficially similar to *Balansia diadema* Möell., which Diehl (1950) classified as *Claviceps diadema* (Möell.) Diehl on account of its having a *Sphacelia* anamorph. The ascostromata of *Balansia claviceps* Speg., the type species of *Balansia*, are stipitate-capitate, (Spegazzini, 1885; Diehl, 1950), and of a broadly similar morphology to those of *Claviceps purpurea* (Fr.: Fr.) Tul. They arise from an effuse primary stroma, which bears an *Ephelis* anamorph, encircling culms and inflorescence primordia of its hosts (Diehl, 1950). Other members of the Balansieae having capitate ascostroma include *Atkinsonella hypoxylon* (Peck) Diehl (Leuchtmann and Clay, 1989), *A. texensis* (Diehl) Leuchtmann & Clay (Morgan-Jones and White, 1989), *Balansia cyperi* Edg., *B. obtecta* Diehl, and *B. pallida*. Of these, the former three have sessile or subsessile ascostromata that are hemispherical to pulvinate in shape, borne directly but localized with sterile areas inbetween, on the primary stromata. Species of *Balansiopsis* also have capitate ascostromata, either sub-stipitate to stipitate, as in *B. pilulaeformis* (Berk. & Curt.) Diehl and *B. asclerotiaca* (P. Henn.) Diehl, or sessile as in *B. guadae* (Rehm.) Höhn. (Diehl, 1950). In *Balansia discoidea* P. Henn., which Diehl (1950) classified as *B. strangulans* forma *discoidea* (P. Henn.) Diehl, ascostromata vary in shape from hemispherical to flat-pulvinate to discoid and sometimes coalesce to form a continuous fertile surface. It is an intermediate form between the capitate species and those having effuse, flat, continuous ascostroma such as *Balansia aristidae*, and *B. strangulans* (Mont.) Diehl. Based in part on the morphology of the ascostroma, Diehl (1950) proposed segregation of species of *Balansia* into two subgenera, *Eubalansia* Diehl and *Dothichloe* Atk.; the former accommodating the capitate taxa and the latter those that are effuse. The usefulness of this is doubtful (Morgan-Jones *et al.*, 1992), especially given that there is a continuum from one condition to the other within the tribe. The effuse stromata of *B. aristidae* and *B. strangulans* encircle culms of their hosts whereas those of *B. epichloe* (Weese) Diehl and *B. henningsiana* (Möell.) Diehl occur on adaxial and abaxial leaf surfaces respectively (Diehl 1950; Rykard *et al.*, 1985; White and Owens, 1992). Likewise, *Myriogenospora atramentosa* (Berk. & Curt.) Diehl, an epiphyte, forms an effuse stroma on adaxial leaf surfaces (Luttrell and Bacon, 1977; Rykard *et al.*, 1985; Hanlin and Tortolero, 1990).

Although the varying external morphology of Balansieae ascostromata is well documented, few detailed studies have been conducted on their development and anatomy. Luttrell and Bacon (1977) reported the ontogeny of the stromata of *Myriogenospora atramentosa* on *Eragrostis hirsuta* (Michx.) Nees. In this species superficial, effuse, relatively thin, linear, plectenchymatous stromata form along the middle of inrolled leaves and immersed perithecia are born in a longitudinal row within them. The perithecia have indistinct walls that bear evanescent paraphyses along the sides and up into the neck which is lined by persistent periphyses in the vicinity of the ostiole. The perithecia originate from ascogonial coils formed among hyaline hyphae below the melanized outer cells of the ascostromata.

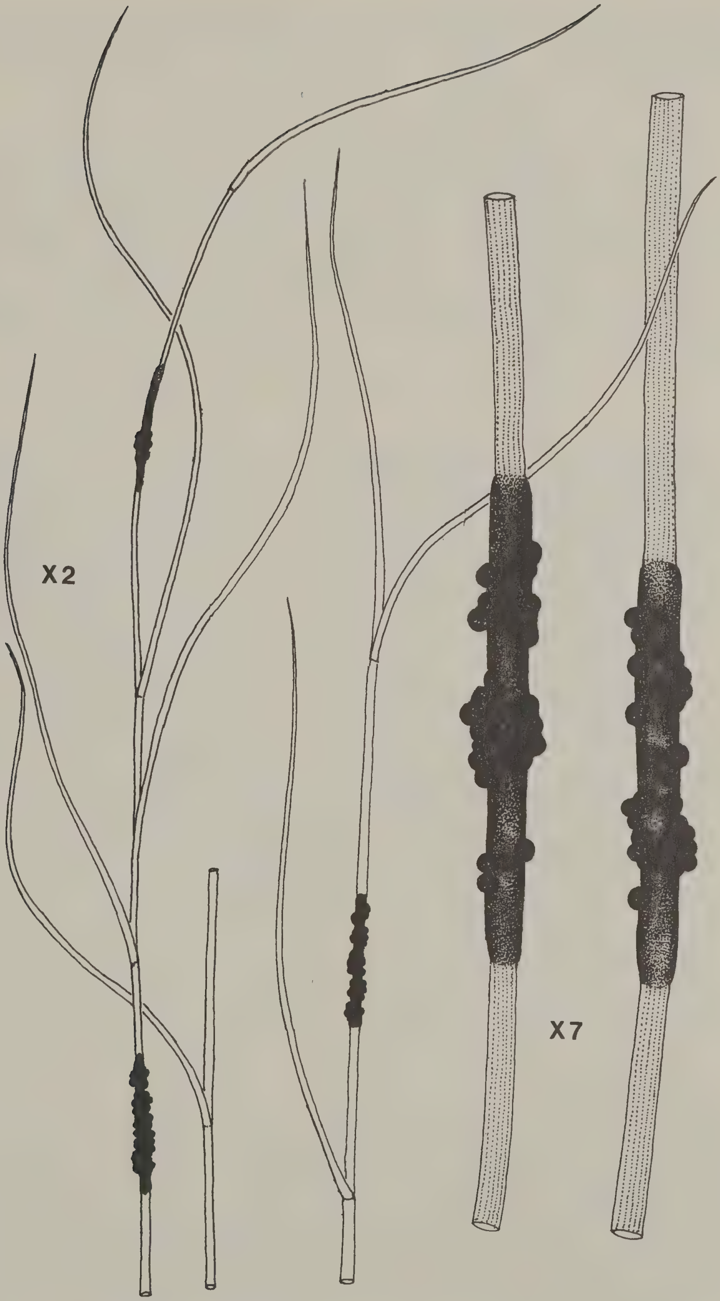


FIGURE 1. *Balansia aristidae* ascostromata on culms of *Aristida purpurascens.*

A study of the development and structure of the ascostromata of *Balansia aristidae* on *Aristida purpurascens* from collections made in Alabama is reported herein.

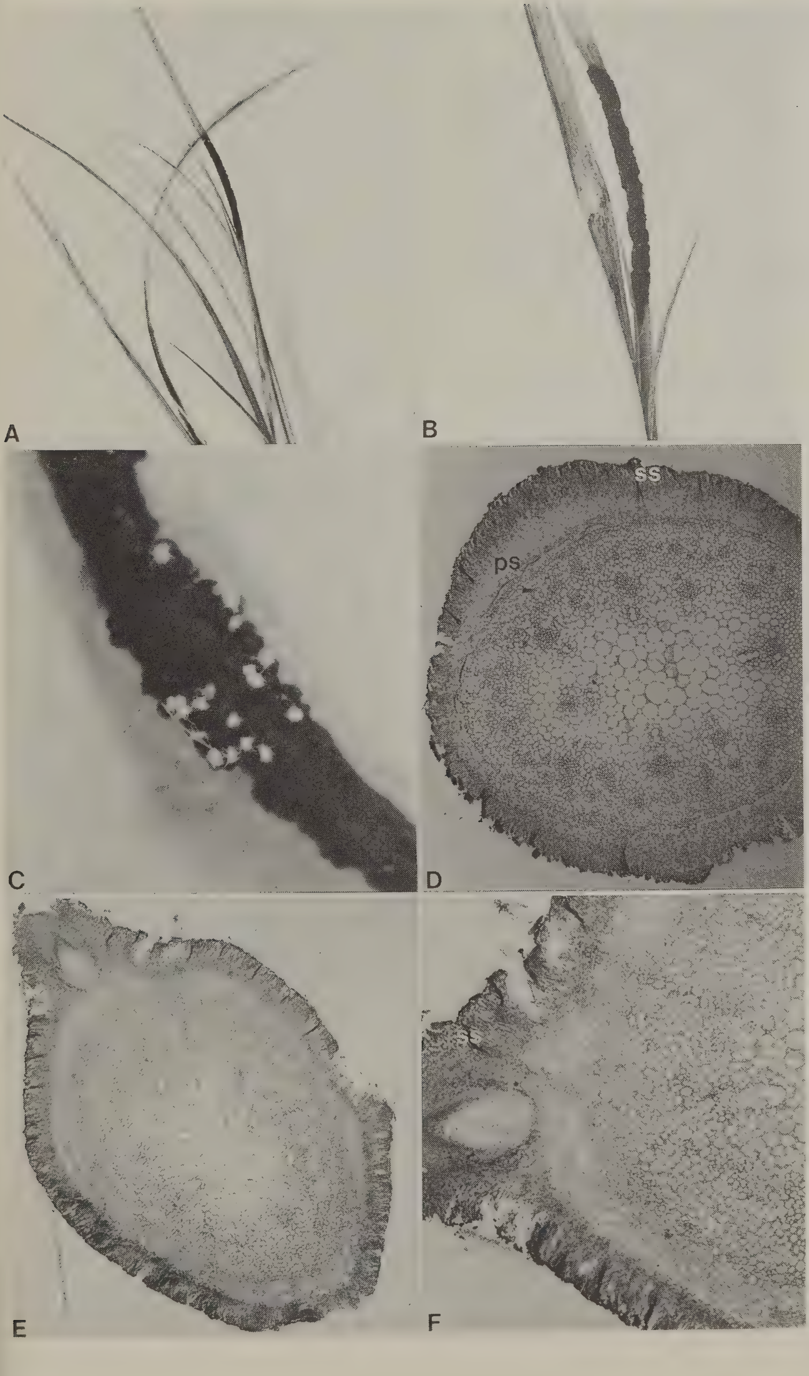
## MATERIALS AND METHODS

Material of *Aristida purpurascens* bearing ascostromata was harvested from plants collected and maintained as described by Phelps *et al.* (1993). Sizes of stromata, including length and thickness, and of perithecia represent averages and range of twenty measurements. Sizes of asci and part-spores are based on forty measurements. Culm segments with ascostromata at various stages of development were harvested and prepared for sectioning. Fixation, dehydration, infiltration and staining procedures were performed as described by Phelps *et al.* (loc. cit.).

## RESULTS

Ascostromata of *B. aristidae* appear on culms as black incrustations (Plate 1, A & B; Figure 1). The primary anamorph stroma, which precedes the teleomorph, becomes differentiated into two zones prior to ascostromal initiation (Plate 1, D). Cells at the surface become tightly compacted and somewhat melanized giving a brownish coloration. Underneath this layer the primary stroma remains more or less hyaline, made up of loosely interwoven hyphae and prosenchymatous in texture but is pseudoparenchymatous near the culm surface (Plate 2, C). Ascostromata are somewhat variable in length, effuse but becoming thicker and slightly pulvinate in places, extending over the whole of the primary stroma or localized with areas of thinner, permanently sterile tissue inbetween (Plate 1, D). Eventually the surface becomes uneven as perithecia develop, giving mature ascostromata a warted or unevenly roughened appearance (Plate 1, C; Figure 1). Ascostromal initiation usually follows cessation of conidiation or may occur concurrently with it or partly overlap the *Ephelis* anamorph in time. The secondary stroma predominantly develops above sterile areas of the primary stroma, although it sometimes extends above conidiomatal remnants, and is largely composed of a layer of interweaving hyphae growing more or less radially (Plate 1, D & E). It varies in thickness (Plate 1, D) and has mainly a prosenchymatous texture but becomes pseudoparenchymatous at and just below the surface when fully mature. The primary and secondary stroma are predominantly about equal in thickness, or the latter may be slightly broader, particularly at sites where perithecia originate (Plate 1, E). Perithecia are initiated in the secondary plectenchyma in the vicinity of the juncture with the primary stromata well below the dark

PLATE 1. Teleomorph of *Balansia aristidae* on *Aristida purpurascens*. A & B, mature ascostroma on host plant [A, X 1; B, X 3]; C, surface of ascostroma showing protruding perithecia and masses of part-ascospores [X 15]; D, host culm cross section showing secondary stroma (ss) and the underlying primary stroma (ps) prior to perithecial development [X 150]; E & F, host culm in cross section showing one perithecium differentiating within secondary stroma (ss) [E, X 100; F, X 200].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stromal surface where cells become more or less isodiametric, thick-walled and heavily melanized (Plate 1, F). Young perithecia originating from ascogonial coils are, at first, poorly defined (Plate 1, F) but later the perithecial walls become more clearly differentiated (Plate 2, A & D) and are composed of elongate cells. A fascicle of asci is formed from a cluster of ascogenous hyphae at the base of the perithecium (Plate 2, E & F) and paraphyses from cells lining its base and sides. As perithecia mature and asci occupy the venter, paraphyses disintegrate. Narrow, persistent periphyses form in the neck (Plate 2, D). Perithecia arise singly (Plate 1, E), or in gregarious and often closely appressed clusters (Plate 1, C; Figure 1). When fully developed the necks and upper halves of the perithecia often protrude and are covered by a narrow layer of stromatic hyphae.

## Taxonomic Description

*Balansia aristidae* (Atk.) Diehl, USDA *Agric. Monogr.*4: 43, 1950.

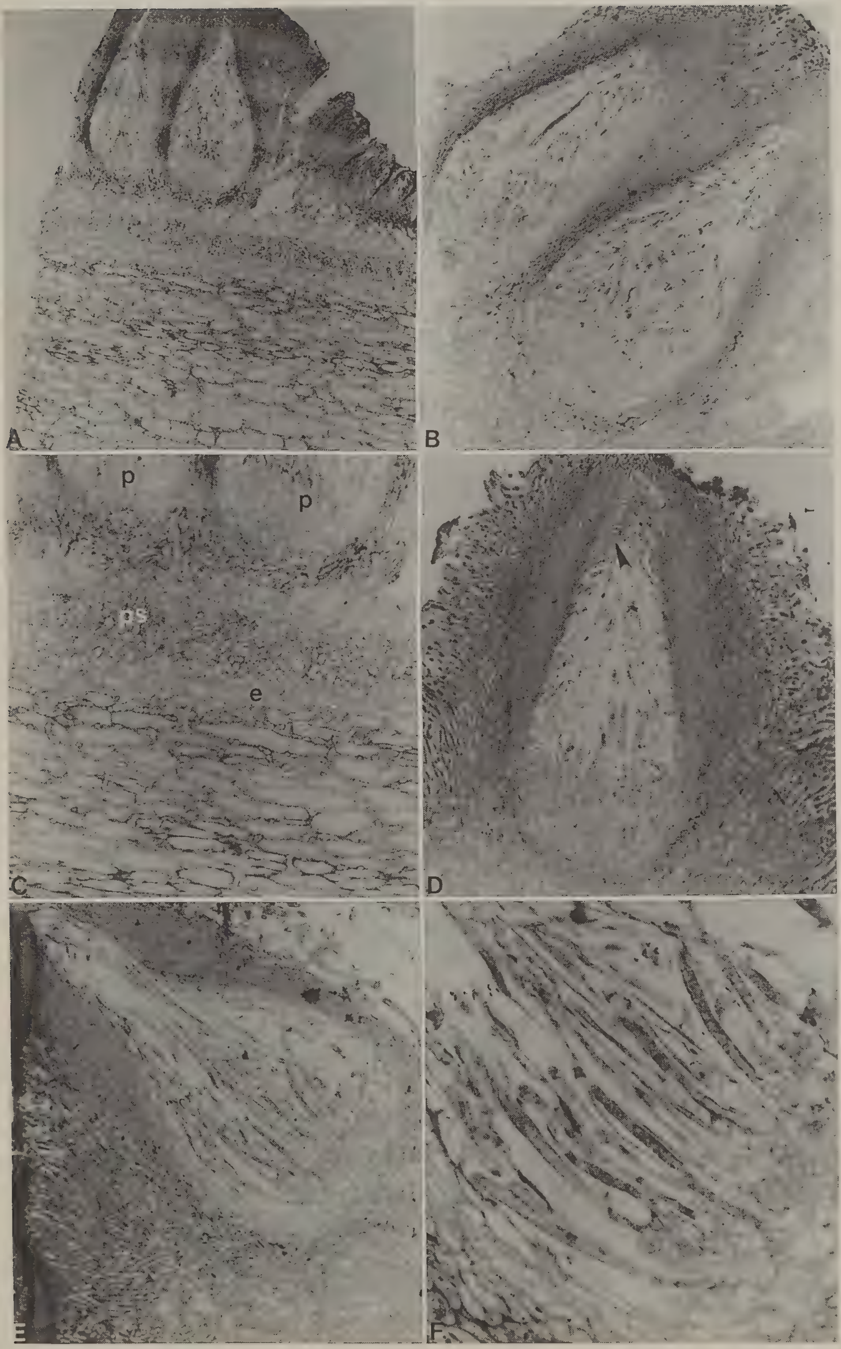
≡ *Dothichloe aristidae* Atk., *Bull. Torr. Bot. Club* 21: 224, 1894.

≡ *Ophiodothis aristidae* Atk. in Sacc., *Hedwigia* 35: 34, 1896.

≡ *Ophiodothis atramentosa* (Berk. & Curt.) Earle var. *aristidae* (Atk.) Earle, *Bull. Torr. Bot. Club* 27: 122, 1900.

Ascostromata encircling culms below nodes as long collars, single or occasionally two on the same culm some distance apart, effuse to slightly pulvinate in places, when mature bearing prominent, protruding perithecia, carbonaceous black, overgrowing primary, anamorph-bearing stromata, (0.7)-1.2-(2.2) cm in length (Plate 1, A-C; Figure 1). Combined thickness of primary and secondary stromata (132)-160-(184) µm; ascostromata (96)-108-(120) µm thick, widening up to 300 µm in proximity to perithecia. Ascostromal texture prosenchymatous to pseudoparenchymatous toward the outside, mainly composed of subhyaline to pale brown hyphae, those at the exposed periphery thick-walled and melanized. Perithecia immersed, protruding, obpyriform to lageniform, slightly flattened laterally when confluent, with longish necks, 216-264 µm high, 84-175 µm in diameter at the broadest part (Plate 1, E & F; Plate 2, A & B); perithecial wall composed of interweaving, slightly thickened elongate cells, 9-19 µm wide (Plate 2, D). Paraphyses filiform, evanescent. Periphyses persistent. Asci arising from a cushion of ascogenous hyphae at the

PLATE 2. Portions of thin sections of *Balansia aristidae* teleomorph on *Aristida purpurascens*. A & B, host culm and perithecia in longitudinal section showing stromal anatomy [A, X 500; B, X 1000]; C, portion of same section showing the host epidermis (e), the overlying pseudoparenchymatous primary stroma (ps), and the bases of two perithecia (p) [X 1000]; D & E, perithecia in longitudinal section showing structure and contents (periphyses indicated in D by an arrowhead) [D, X 1000; E, X 100]; F, portion of perithecium in longitudinal section showing ascogenous hyphae, asci and paraphyses [X 2500].


A
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base of the perithecium, sub-cylindric, tapering to a narrow base 140-250 µm x 5-6 µm (Plate 2, E & F), each containing eight ascospores. Ascospores filamentous, hyaline, 7-septate, disarticulating into separate, 1-septate, part-spores, each (21)-28-(34) µm long, 1-1.5 µm wide.

On culms of *Aristida* spp.; North, Central and South America.

Collections examined: on *A. purpurascens* Poir., Auburn, Lee County, Alabama, 1891, B. M. Duggar, type, CUP, FH; on *A. purpurascens*, Campus of Auburn University at Montgomery, Montgomery County, Alabama, August 1991, G. Morgan-Jones, R. A. Phelps and J. F. White, Jr., AUA; same host and locality, May 1992, R. A. Phelps and M.R. Owsley, AUA, BPI.

## DISCUSSION

Although no other detailed study of the development, structure and anatomy of Balansieae ascostromata have been made, except for those on *Epichloe typhina* (Doguet, 1960) and *Myriogenospora atramentosa* (Luttrell and Bacon, 1977), it is assumed that all are essentially similar even though those of the capitate-stipitate forms are more elaborate. They resemble the perithecial stroma of *Claviceps purpurea* and perithecial centrum ontogeny in the Clavicipitaceae is probably uniform. Cytological investigation of perithecial development in *C. purpurea* (Killian, 1919) and in *C. microcephala* (Wallr.) Tul. (Kulikarni, 1963) has shown that club-shaped, multinucleate antheridia and ascogonia undergó plasmogamy in the outer zone of the capitate ascostroma. Ascogenous hyphae develop from the base of each ascogonium forming croziers at their tips. Luttrell and Bacon (1977) described perithecia of *M. atramentosa* as originating from deeply staining ascogonial coils in the hyaline tissue below the dark surface of the developing stroma.

The ascostromata of *B. aristidae*, as indicated previously, closely resemble those of *B. strangulans* except for the greater prominence of the perithecia in surface view. There are also differences in the *Ephelis* anamorphs of the two species. Although they appear to be closely related, their designation as two separate species seems warranted. Studies on the development of the ascostroma of *B. strangulans* would help confirm this. *Balansia hemicrypta* Diehl, described from florets of *Aristida* species collected in New Mexico, Texas, Brazil and Venezuela, was considered by Diehl (1950) to be a distinct species and not a depauperate, reduced form of *B. aristidae*, despite occurring on the same host genus. It produces an *Ephelis* anamorph from a thin, white hyphal mat formed within the lemma of the host plant inflorescence, followed by a small blackish brown ascostroma. Nothing further is known of its relationship with its hosts. Its presence, however, causes dwarfing of plants and inflorescences of *Aristida glauca* (Nees) Walp. Interestingly, none of the species of *Aristida* on which it has been recorded are known to be hosts of *B. aristidae*. No material of *B. hemicrypta* bearing mature perithecia has ever been collected (Diehl, 1950).

*Dothidella aristidae* (Schw.) Ell. & Everh., which produces superficially similar, black, sterile mats of hyphae on leaves and culms of *Aristida* spp. in the southern United States, is a different fungus.

## ACKNOWLEDGMENTS

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# SYSTEMATIC AND BIOLOGICAL STUDIES IN THE BALANSIEAE AND RELATED ANAMORPHS. VII. HOST-PATHOGEN RELATIONSHIP OF ERAGROSTIS CAPILLARIS AND BALANSIA EPICHLOE

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## ABSTRACT

A review of current knowledge of *Balansia epichloe* (Weese) Diehl, including nomenclature, host range, geographical distribution, and the nature of the relationship with its hosts, is made. A study of its growth habit on *Eragrostis capillaris* (L.) Nees and *E. elliottii* Watson in Alabama is reported. Distribution of endophytic hyphae, particulars of hyphal egress and stromal development were investigated in the former. The reported occurrence on the latter represents a new host record.

## INTRODUCTION

The fungus presently known as *Balansia epichloe* was first given the name *Sphaeria epichloe* Kunze for a specimen issued in 1837 by C. E. von Weigelt in his unnumbered *Fungi Exsiccati*, distributed by Gustav Kunze. Since no adequate diagnosis was published, Diehl (1950) considered this binomial to be a *nomen nudum*. Saccardo (1892) used the name *Botryosphaeria epichloe* (Kunze) Sacc. for a Weigelt specimen housed in the herbarium of the Jardin Botanique de l'Etat, Brussels (BR). It is evident, however, that his description was based on a secondary fungus and not the *Balansia*. *Dothidea atramentaria* Berk. & Curt. is another name that has apparently been applied to specimens of *Balansia epichloe* (Berkeley, 1876). The epithet '*atramentaria*' is assumed to have been an orthographic error for '*atramentosa*'. The species of Balansieae now known as *B. henningsiana* (Möell.) Diehl and *Myriogenospora atramentosa* (Berk. & Curt.) Diehl have, in the past, been confused with each other and with *B. epichloe*. Consequently, much misapplication of names has occurred. All three occur on grass leaves and form effuse, black ascostromata. Weese (1919) provided the first description of *B. epichloe* proper, proposing the name *Dothichloe epichloe* for it. Hence, he was regarded by Diehl (1950) as the validating author for the epithet '*epichloe*'. Diehl had previously (1939) established the name *Dothichloe limitata* for *Balansia epichloe* on the mistaken

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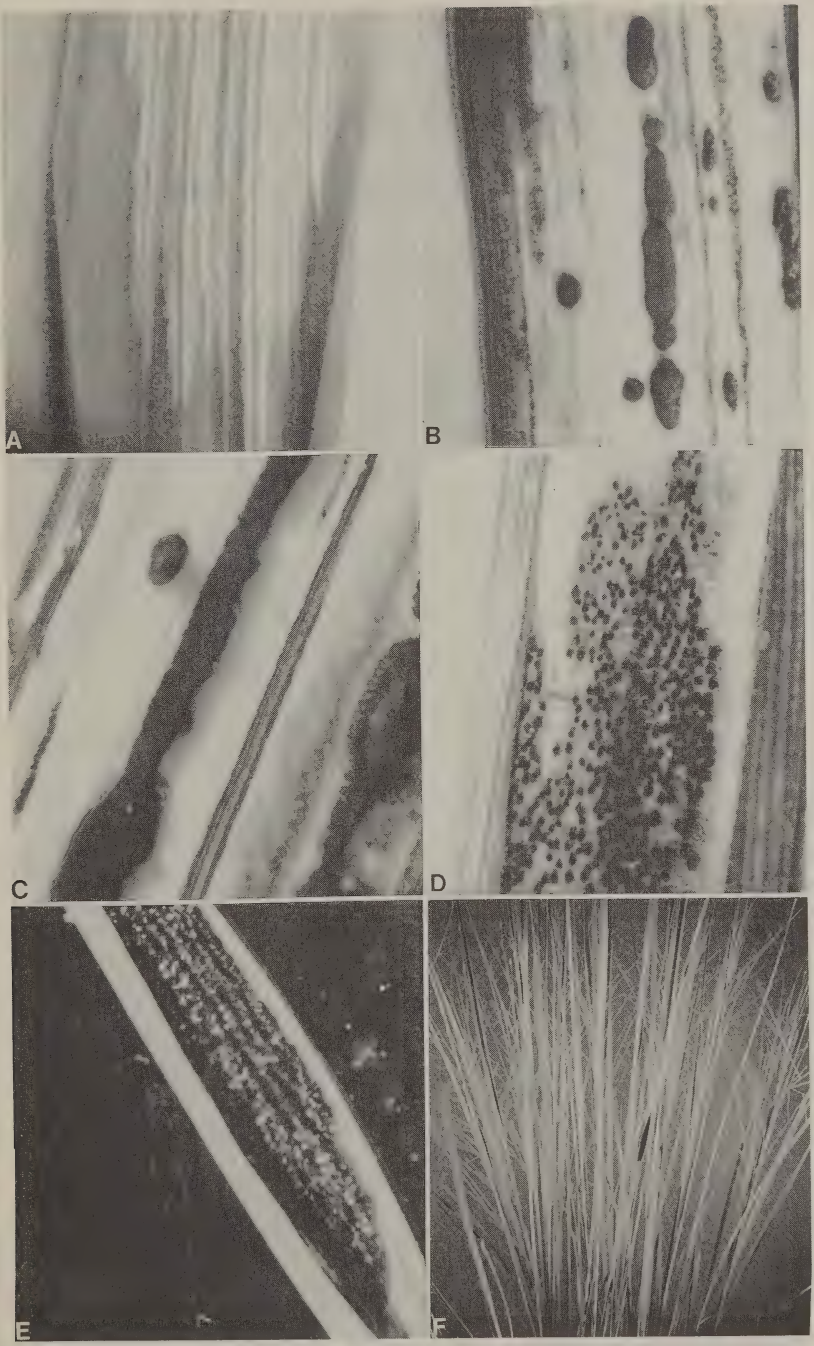
assumption that the description published by Saccardo (1892) was based on the fungus to which Kunze had applied *S. epichloe*. If this were the case, a new specific epithet would have been necessary. However, examination of additional Weigelt material by Diehl (1950) corroborated Weese's description, whereby Diehl transferred the epithet to *Balansia*.

*Balansia epichloe* is known to occur on a relatively wide range of host grasses, including species of the following genera: *Andropogon* L., *Calamagrostis* Adans., *Chasmanthium* Link, *Chloris* Sw., *Ctenium* Panz, *Eragrostis* Wolf, *Gymnopogon* P. Beauv., *Panicum* L., *Sporobolus* R. Br., *Thrasya* H. B. & K. [= *Panicum*] and *Triodia* R. Br. (Diehl, 1950; Rykard *et al.*, 1985). It appears to be common in the southeastern United States on *Eragrostis* spp. and on *Sporobolus indicus* (L.) R. Br. [= *Sporobolus poiretii* (Roem. & Schult.) Hitchc.]. It has a geographical distribution in the United States extending from North Dakota and Wisconsin to Virginia and all southeastern states from North Carolina to Louisiana (Diehl, 1950). It has also been reported from Central and South America, including Brazil, although comparatively few collections have been made in those areas.

Grass plants infected by *B. epichloe* generally show no loss of vigor or coloration change and, other than the appearance of stromata on upper leaf surfaces, show no symptoms of infection (Diehl, 1950). Although attempts to determine the route and mode of infection were made by Diehl (1950), including artificial inoculation of *Ctenium aromaticum* (Walt) Wood plants grown in a greenhouse, no conclusions in this regard could be reached. Evidence of systemic infection suggested entry through stigmata and subsequent seed transmission but this seems doubtful. Rykard *et al.* (1985) found the mycelium of *B. epichloe* to be systemic in culms and leaves of *Chasmanthium laxum* (L.) Yates and *Sporobolus indicus* but no hyphae were observed to infect seeds. Hyphae were found to ramify intercellularly in both culm and leaf tissues, including the pith and mesophyll. No indication was given of the relative abundance of fungal biomass at the various sites. Hyphae were found to emerge inbetween epidermal cells and also through stomata prior to elaboration of superficial stromata. Some hyphae were found to penetrate laterally inbetween the epidermal cell walls and the cuticle, the latter of which subsequently disintegrated. White and Owens (1992) confirmed some of the observations made by Rykard *et al.* (1985), including the absence of mycelium in inflorescences, and speculated on nutritional aspects of the biology of *B. epichloe*. Endophytic hyphae were found in vascular bundles of infected leaves of *S. indicus*, including inbetween xylem and phloem cells, as well as in mesophyll tissues. It was inferred that an initial epiphytic growth phase precedes development of hyphal bridges that connect endophytic hyphae with the superficial primary stromata. The primary stroma was referred to as a subiculum. They showed the fungus to be heterothallic.

PLATE 1. Stromata of *Balansia epichloe* on leaf blades of *Eragrostis capillaris*. A, early stage of primary stroma formation showing striate appearance [X 10]; B & C, *Ephelis* conidiomata on primary stroma [B; X 10; C; X 20]; D, young perithecia developing directly from sterile primary stroma [X 10]; E, mature ascostroma [X 5]; F, mature ascostroma as seen in nature.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A review of known host-pathogen relationships among the Balansieae has recently been published and the nature of the association between *Balansia aristidae* (Atk.) Diehl and its host grass *Aristida purpurascens* Poir. has been reported (Phelps *et al.*, 1993). During the course of collecting species of *Balansia* in the southeastern United States, we encountered populations of *B. epichloe* on two hosts, *Eragrostis capillaris* and *E. elliottii*, in Alabama. This has afforded us an opportunity to study the host-fungus relationship in more detail and this is reported upon herein.

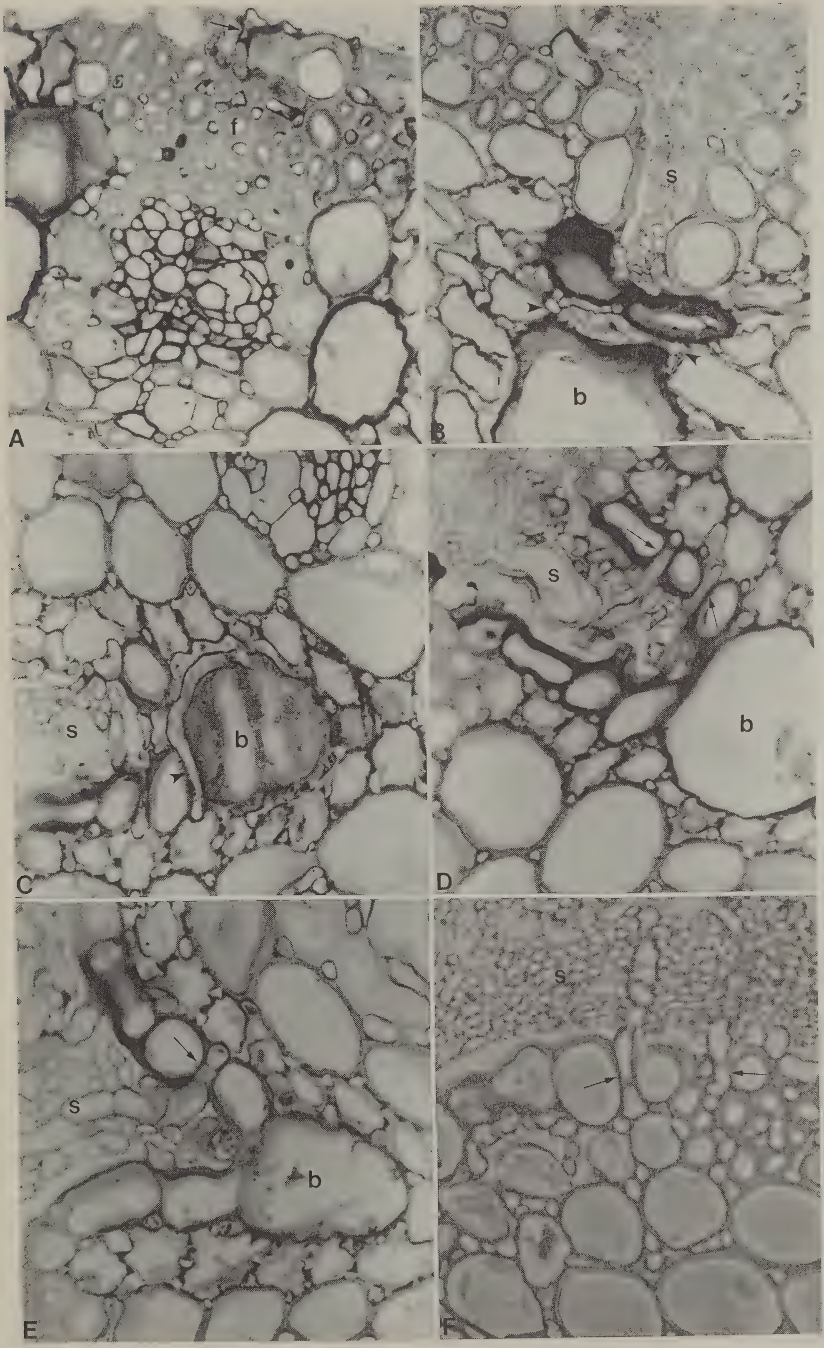
## MATERIALS AND METHODS

Plants of *Eragrostis capillaris* and *E. elliottii* bearing primary *Ephelis* conidial stromata and secondary, mature perithecial ascostromata of *Balansia epichloe* were observed and collected in Lee and Geneva Counties, Alabama, respectively, in July, 1991. Voucher specimens of each collection have been deposited in the Auburn University Mycological Herbarium (AUA) and at BPI. Transplants of infected plants from each site were grown in 15 cm diameter pots containing a local sandy loam. Plants were kept for two years in a Conviron growth chamber, a greenhouse facility, or outdoors under natural conditions. All maintenance, research procedures, and observations were conducted as described by Phelps *et al.* (loc. cit.). For investigation of endophytic growth and hyphal egress, material of *B. epichloe* on *E. capillaris* was used. To investigate the presence of *B. epichloe* in the crowns of infected plants, some plants were trimmed to the soil line, allowed to grow back, and subsequently sampled.

## RESULTS

The occurrence of *Balansia epichloe* on *Eragrostis elliottii* represented a new host record. At the collecting sites host plants of both *E. capillaris* and *E. elliottii* were found growing in thick, solitary clumps, arising from hard, perennial crowns, and often separated by several meters. Most plants produced robust leaves and culms, with several loose, panicle-type inflorescences per clump (Plate 1, F). During mid-summer, one or a few plants at each site bore conspicuous, black, secondary ascostromata of *B. epichloe* on the adaxial surface of some leaves (Plate 1, E &F). Such plants appeared healthy except

PLATE 2. Portions of thin sections showing intercellular and stromal hyphae of *Balansia epichloe* near the surface of stroma-bearing leaf blades of *Eragrostis capillaris*. A, portion of cross section showing a hypha (indicated by arrow) emerging from the abaxial leaf surface opposite the stroma, (f, phloem fiber cap); B & C, portions of cross sections showing intercellular hyphae (indicated by arrowheads) associated with bulliform cells (b) and stromal hyphae (s) within the longitudinal groove [A-C; X 1000]; D & E, portions of cross sections showing bulliform cells (b), and also hyphal bridges (indicated by arrows) between the endophytic mycelium and stromal tissue (s) within longitudinal grooves [D; X 1200; E; X 1400]; F, portion of cross section through a perithecial stroma showing hyphal bridges (indicated by arrows) inbetween epidermal cells outside the longitudinal grooves [X 1400].


f
A
s
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D
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b
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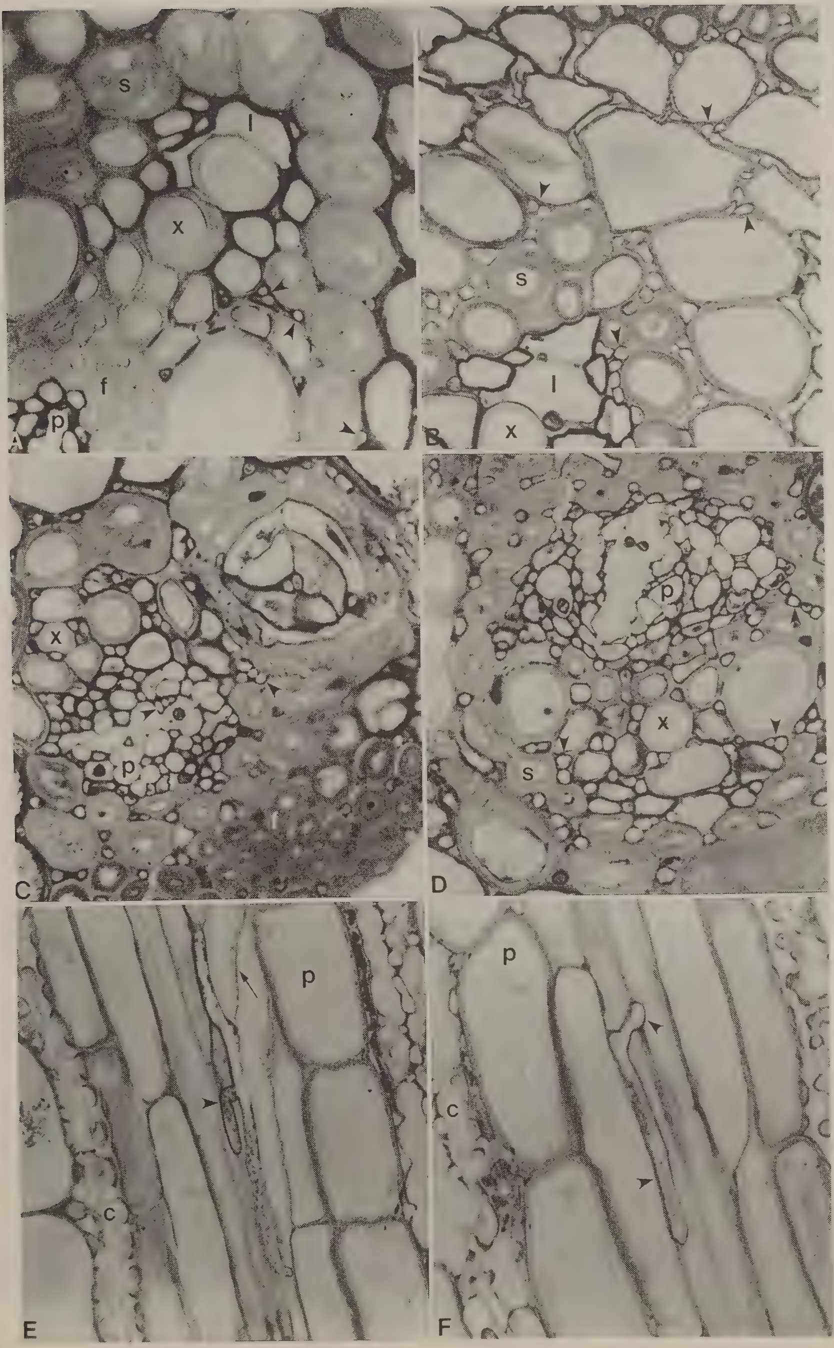
s
F

for failure to flower. Although leaf areas directly beneath developing stromata had become somewhat chlorotic, all surrounding tissue, including the abaxialleaf surface opposite the stroma, remained normal in appearance. The number of stromata occurring on a single clump ranged from one to many. Most stroma-bearing leaves bore only one stroma, but two per leaf was not uncommon. The first stroma produced on each leaf was generally located approximately halfway up the fully expanded blade. The second stroma, when present, was situated several centimeters away toward the leaf apex.

In addition to the conspicuous ascostromata, closer examination of the plants collected in the field revealed many whitish to pale buff, primary stromata, 1.0 to 3.0 cm in length, present on exposed leaf surfaces or wrapped within the younger leaves which had not yet spatially diverged from culms. Initially, superficial primary stromal primordia in the form of thin, white, delicate, repent hyphal mats with surfaces first appearing striate (Plate 1, A) but later becoming mostly uniform, developed near leaf tips. Young primary stromata were observed in this position on succulent leaves of all ages, ranging from new leaves only a few centimeters long to older leaves already bearing other stromata. *Ephelis* conidiomata formed on the primary stroma (Plate 1, B & C), followed by development of an overlying ascostroma at the same site (Plate 1, E). In other instances, *Ephelis*-bearing primary stromata persisted, or dried up, with no further development. Ascostromata occasionally formed directly from sterile primary stromata (Plate 1, D).

These observations of *B. epichloe* and its hosts apply to pot cultures grown under natural conditions as well as to plants at the collection sites. When plants were grown under optimal growth conditions, however, host-fungus interactions were altered in certain respects. Under such conditions, including appropriate fertilization, flowering frequency and seed production increased. A substantial increase in stromal production also occurred, as many as four forming on a single leaf. Few, if any, leaves failed to develop stromata. Conidiomata were better developed and more prominent (Plate 1, B & C), and production of *Ephelis* macroconidia appreciably increased. Unmelanized primary stromata and productive *Ephelis* fructifications persisted until natural senescence of the leaves bearing them. When stroma-bearing plants were deprived of water or nutrients to the point of wilting or yellowing, respectively, developing primary stromata aborted and no more were initiated. When optimal

PLATE 3. Portions of thin sections showing intercellular hyphae (indicated by arrowheads) of *Balansia epichloe* in stroma-bearing leaf blades of *Eragrostis capillaris*. A, vascular tissue in cross section directly below an immature ascostroma showing hyphae growing longitudinally, (f, fibers; l, lacuna; p, phloem bundle; s, inner bundle sheath cell; x, xylem vessel) [X 1400]; B-D, vascular and ground tissue in cross section through primary stroma showing multiple hyphae in intercellular spaces, (f, fiber; l, lacuna; p, phloem bundle; s, inner bundle sheath cell; x, xylem vessel) [B; X 1400; C; X 1000; D; X 1200]; E & F, portions of a longitudinal section through an immature perithecial stroma showing septate hyphae and nearby chlorenchyma (c), parenchyma (p), and xylem (indicated by arrow) cells [X 1400].


s
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E
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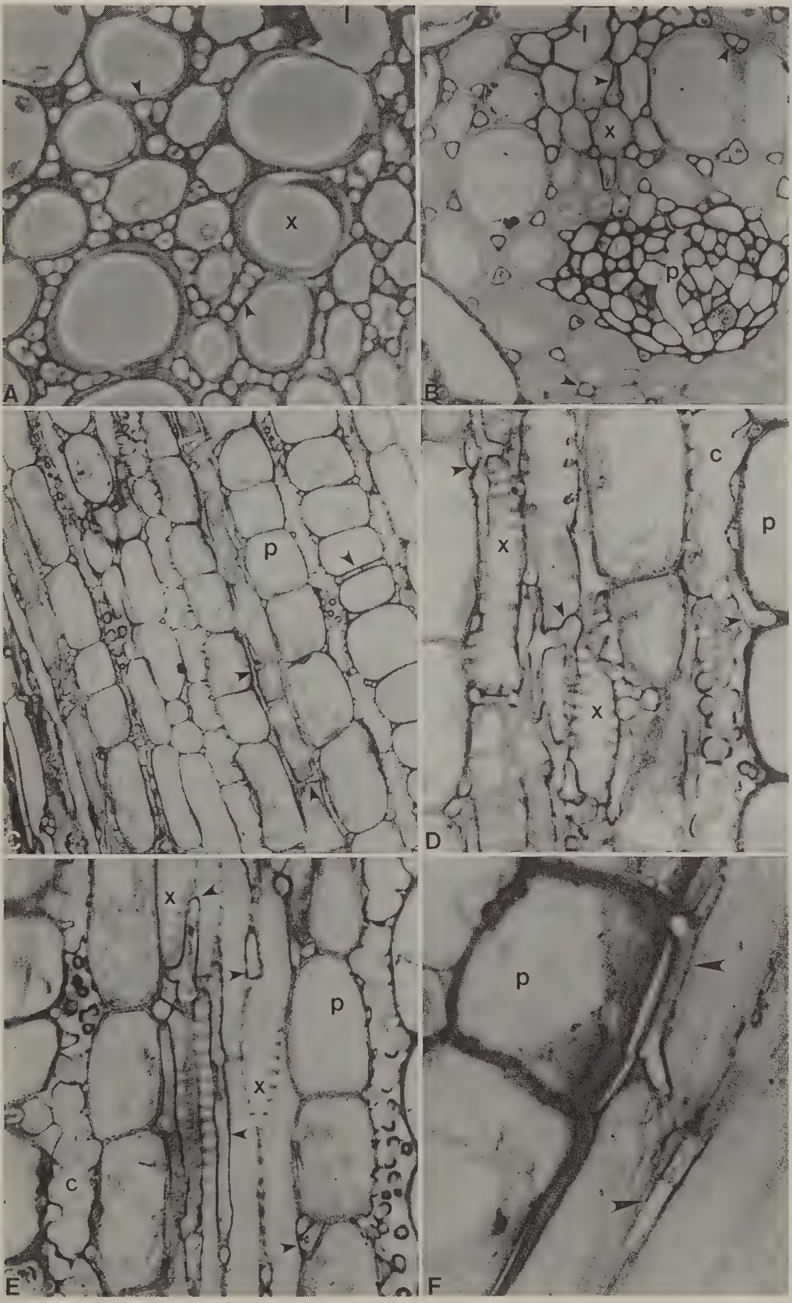
c
F

growth conditions were restored, a synchronized crop of new primary stromata appeared on new leaves within 48 hours of the plants' recovery. When stroma-bearing plants were trimmed to soil level, thus removing all aerial portions, new leaves always developed stromata. Under greenhouse and growth chamber conditions, mature, fertile ascostromata were rarely formed.

Examination of leaf sections indicated that egress and stromal development are preceded by systemic hyphal growth intercellularly in leaf tissue. Until stromal initiation, hyphae grow longitudinally for the most part, weaving inbetween cells of both vascular and ground tissue. Prior to egress, endophytic hyphae build up in leaf tissue near the leaf tip. Hyphae egress from the adaxial surface, particularly inbetween epidermal cells and bulliform cells of the longitudinal leaf grooves (Plate 2, D & E), giving rise to epiphytic mycelium. Occasionally hyphae pass outward inbetween guard cells of stomata. Initially, longitudinal grooves are filled with hyaline, loose, prosenchymatous, hyphal tissue (Plate 2, B, D, & E), the primary stromal primordium. This gives the striate appearance when viewed from above (Plate 1, A). Later, the stroma becomes a dense and compact, more or less uniform layer which arises mainly by further growth of mycelium already present in the longitudinal grooves, but also from further hyphal egress from costal regions inbetween the grooves (Plate 2, F). Eventually, the stroma covers most or all of the width of the adaxial leaf surface, commonly extending almost to the edge. Rarely, hyphae may egress from the abaxial leaf surface opposite the stroma (Plate 2, A). Such hyphae, however, never give rise to epiphytic growth. Virtually all tissues of the leaf become saturated with hyphae as egress and stroma formation progress (Plate 3, B-F; Plate 4, A-E). Throughout fungal biomass build-up within plant tissue beneath developing stromata, hyphal growth remains predominantly longitudinal (Plate 3, B & F; Plate 4, A). Lateral hyphal growth does, however, occur in this region especially near the epidermis of the adaxial leaf surface (Plate 2, C). Host plant cells remain undamaged and apparently healthy (Plate 4, A) even during the most extensive stages of mycelial build-up when hyphae growing longitudinally, side-by-side, virtually surround them.

As noted above, multiple stromata may develop on a single leaf. The stromal development process occurs repetitively as the leaf increases in length. In young leaves 3 to 4 cm long, the region of hyphal build-up associated with the first stroma occupies, at least initially, most of the area inbetween the base of the leaf blade and its apex. As the leaf elongates, the stroma typically remains

PLATE 4. Portions of thin sections showing intercellular hyphae (indicated by arrowheads) of *Balansia epichloe* in stroma-bearing leaf blades of *Eragrostis capillaris*. A-E, portions of sections through mature perithecial stromata; A & B, vascular tissue in cross section showing extensive intercellular hyphal growth, (1, lacuna; p, phloem bundle; x, xylem vessel) [A; X 1400; B; X 1200]; C-E, tissue in longitudinal section showing hyphae inbetween various cell types, (c, chlorenchyma cell; p, parenchyma cell; x, xylem vessel) [C; X 800; D & E; X 1400]; F, portion of longitudinal section through leaf area inbetween two stromata (3 cm from each) showing hyphae near a parenchyma cell (p) [X 1800].


A
B
C
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x
l
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centrally located on the blade. Hyphal growth above the stroma remains sparse until initiation of a second stroma which, when present, forms severalcentimeters distal to the first. The areas of abundant endophytic fungalbiomass underlying stromata on a single leaf are thus connected by sparse, but continuous, hyphae (Plate 4, F). Stromata continue to form in this way until senescence of the leaf tip.

## DISCUSSION

The host-pathogen relationship of *Balansia epichloe* on *Eragrostis capillaris* is not unlike that of *B. aristidae* (Atk.) Diehl on *Aristidae purpurascens* Poir. (Phelps *et al.* 1993) except that the endophytic mycelium of the former predominates in the leaves rather than in the culm. Likewise, *B. epichloe* differs in forming flat, primary anamorph stromata and secondary ascostromata exclusively on upper leaf surfaces unlike those of *B. aristidae* which encircle culms. In both species, infection and subsequent endophytic mycelial growth prior to hyphal egress are more or less symptomless but considerable energy loss is evident by the fact that stroma-bearing plants in nature have reduced fecundity and frequently do not flower. Increased flowering in fertilized plants indicates that failure to form inflorescences under normal conditions results from mineral deficiencies, or more likely from the associated energy shortfall.

The position of ascostromata on leaves appears to depend on plant growth at the time of and following hyphal egress. White *et al.* (1991) suggested that formation of *B. epichloe* near the middle of leaf blades may be in part determined by concentrations of sugars during early development. Where a sequence of two or more stromata is produced in acropetal succession on a single leaf, hyphal egress is probably determined by degree of proximal mycelial build-up, which in turn is dependent upon available nutrients. In the vicinity of the initial stroma, available sugars presumably become depleted, so that further stromal development can only occur at a site some distance away, in the direction of the apex. The sequence of stromal initiation, maturation, and final positioning on leaves appears indicative of concurrent leaf blade elongation. Anatomical data indicate that grass leaf blade growth occurs as a result of intercalary meristematic activity toward its base (Gill and Vear, 1966). More work is necessary to completely understand the relationship between stromal position and leaf elongation.

Lack of ascostromatal development following primary stromata formation under greenhouse and growth chamber conditions probably reflects heterothallism. White and Owens (1992), in studies of the mating system of *B. epichloe*, demonstrated the role of *Ephelis* conidia as spermatia. Variable insect vectoring was suggested to be responsible for irregular occurrence of perithecial production. In order for ascostromata to develop, cross-inoculation between compatible *Ephelis* conidia and primary stromata of an opposite mating type is necessary.

Whether or not *B. epichloe* is readily spread horizontally in nature by conidia or part-ascospores is difficult to determine. Judging from the fact that only a few plants of both *E. capillaris* and *E. elliottii* out of many at the collection sites, although in relatively close proximity to one another, appeared to be infected suggests that this may not occur with any frequency. Formation of stromata on new leaves produced following severe pruning indicates the systemic nature of the endophyte. As is the case in *Balansia aristidae*, it seems possible that *B. epichloe* perennates in the crown tissues of its hosts from one year to the next.

## ACKNOWLEDGMENTS

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# NOTES ON THE PLEOMASSARIACEAE

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## SUMMARY

A cladistic analysis of species in the Pleomassariaceae provides evidence to accept *Splanchnonema* (including *Pleomassaria*) and *Asteromassaria*, and to add *Eopyrenula*, *Kirschsteiniothelia*, and *Macrovalsaria* to the family. Keys to genera and species are provided. *Asteromassaria alni*, *Splanchnonema horizontale*, *S. quercicola*, and *S. striatulum* are described as new species. New combinations are proposed for *Kirschsteiniothelia phileura*, *Splanchnonema carpini*, *S. hesperium*, *S. holoschistum*, *S. maximum*, *S. monospermum*, *S. siparium*, *S. thujinum*, and *S. ulmicola*.

Three genera -- *Splanchnonema*, *Pleomassaria*, *Asteromassaria* -- are generally recognized in the Pleomassariaceae, although Barr (1982) and Crivelli (1983) observed that the genera were closely related and difficult to separate. Aptroot (1991) assigned the lichenized species of *Eopyrenula* to this family, and concluded that *Splanchnonema* could encompass all the other species. Species of *Kirschsteiniothelia*, originally placed in the Pleosporaceae (Hawksworth 1985, Barr 1987, Eriksson and Hawksworth 1991), are instead more closely related by substrate preference, morphology, and anamorphs to members of the Pleomassariaceae. Although the ascospores are consistently only one-septate, the formation of four to six large cuboid refractive regions suggest distosepta in many collections of *K. aethiops* (Berk. & M. A. Curtis) D. Hawksw. (Barr, personal observations) and are strong indications that the genus should be included in the Pleomassariaceae. Another taxon that seems suitably accommodated in this family is the pantropical *Macrovalsaria macrospora* (Mont.) Sivan., arranged by Sivanesan (1975) and by Arx and Müller (1975) in the Pleosporaceae, but referred only to the Dothideales by Eriksson and Hawksworth (1991).

All of these taxa have in common saprobic or lichenized habit in woody branches, ascomata with a cellular peridium, the cells nonsclerotial, ascus wall thick toward the apex, pseudoparaphyses cellular, ascospores mostly brown but occasionally pallid to light brown, thick walled, one or several distoseptate with the first-formed septum euseptate. The anamorphs where known form brown, often distoseptate conidia holoblastically in pycnidial or acervular conidiomata or from conidiophores associated with ascomata.

A cladistic analysis was attempted of 45 taxa assigned to the above-mentioned genera. These taxa include North American and European species. Information on several species: *Pleomassaria phoenicis* C. R. Patil & C. Ramesh, *P. capparidis* Byzova, and *P. fagi* E. S. Husseinov, has not been available to me. *Asteromassaria tetraspora* M. D. Mehrotra & Sivan. (Mehrotra and Sivanesan 1989) in branches of *Tetrameles* in India, is distinctive in its four-spored asci. *Asteromassaria verruculosa* Sivan. (Sivanesan 1988) is anomalous: ascomata are seated in a stromatic tissue erumpent from leaf spots, and ascospores are relatively short and narrow. Illustrations of this taxon are somewhat suggestive of some species of *Gibbera* in the Venturiaceae. A few species are excluded because they are lichenized, thus *Pleomassaria luzonensis* (Henn.) Teng belongs in *Anthracothecium* (Barr 1985), *Splanchnonema superans* (Müll. Arg.) O. E. Erikss. is a synonym of *Architrypethelium seminudum* (Mont.) Aptroot (Aptroot 1991).

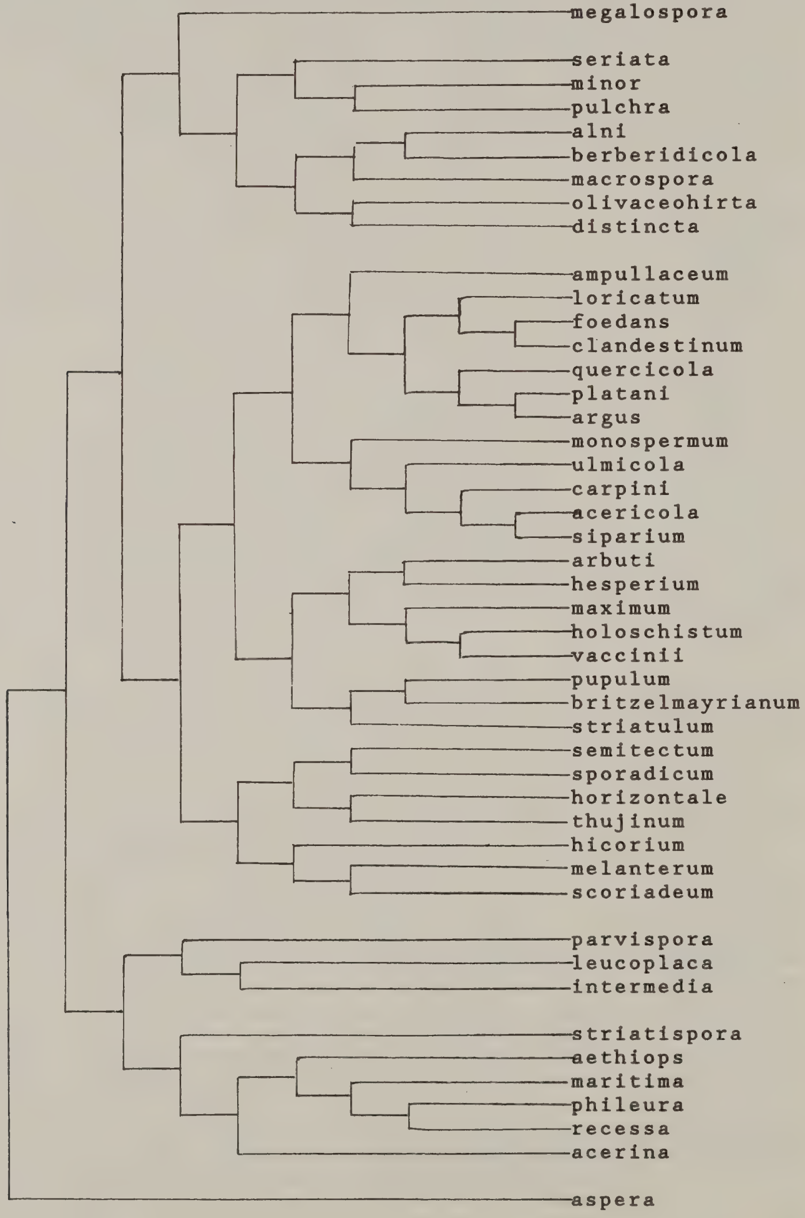
The following character states provided useful information. In a preliminary analysis, some of the characters proved to be linked, as in numbers 2, 3, and 5 below and for that reason the characters are treated as one.

1. Ascomata nonlichenized = 0; lichenized = 1
2. Ascomata applanate, erumpent superficial = 0; sphaeroid to globose, immersed erumpent = 1
3. Asci oblong clavate and ascospores biseriate = 0; cylindric and ascospores uniseriate = 1
4. Ascospores brown = 0; hyaline or lightly pigmented = 1
5. Ascospores obovoid, first septum slightly or strongly submedian = 0; ellipsoid fusoid, first septum median = 1
6. Ascospores when obovoid with slightly submedian first septum = 0; strongly submedian first septum = 1
7. Ascospores up to 30 um long = 0; more than 30 um long = 1
8. Ascospores one septate = 0; more than one septate = 1
9. Ascospores transversely septate = 0; muriform = 1
10. Ascospore wall smooth = 0; ornamented = 1

A data matrix was constructed utilizing these ten character states for 45 presumed members of the Pleomassariaceae. *Dothidotthia aspera* (Ellis & Everh.) M. E. Barr (Botryosphaeriaceae) serves as outgroup species.

| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| aspera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| acericola | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| acerina | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| aethiops | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| alni | 0 | 1 | 0 | 1 | 1 |  | 1 | 1 | 0 | 1 |
| ampullaceum | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| arbuti | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| argus | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| berberidicola | 0 | 1 | 0 | 0 | 1 |  | 1 | 1 | 0 | 1 |
| britzelmayrianum | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| carpini | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| clandestinum | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| distincta | 0 | 1 | 0 | 0 | 1 |  | 1 | 1 | 0 | 0 |
| foedans | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| hesperium | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| hicorium | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| holoschistum | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| horizontale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| intermedia | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| leucoplaca | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| loricatum | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| macrospora | 0 | 1 | 0 | 0 | 1 |  | 1 | 1 | 0 | 1 |
| maritima | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| maximum | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| megalospora | 0 | 0 | 1 | 0 | 1 |  | 1 | 0 | 0 | 1 |
| melanterum | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| minor | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| monospermum | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| olivaceohirta | 0 | 1 | 0 | 0 | 1 |  | 1 | 1 | 0 | 0 |
| parvispora | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| phileura | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| platani | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| pulchra | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| pupulum | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| quercicola | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| recessa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| striatulum | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| scoriadeum | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| semitectum | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| seriata | 0 | 0 | 0 | 0 | 1 |  | 1 | 0 | 0 | 1 |
| siparium | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| sporadicum | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| striatulum | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| thujinum | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| ulmicola | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| vaccinii | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |

The most parsimonious cladogram is presented here.


megalospora
seriata
minor
pulchra
alni
berberidicola
macrospora
olivaceohirta
distincta
ampullaceum
loricatum
foedans
clandestinum
quercicola
platani
argus
monospermum
ulmicola
carpini
acericola
siparium
arbuti
hesperium
maximum
holoschistum
vaccinii
pupulum
britzelmayrianum
striatulum
semitectum
sporadicum
horizontale
thujinum
hicorium
melanterum
scoriadeum
parvispora
leucoplaca
intermedia
striatispora
aethiops
maritima
phileura
recessa
acerina
aspera

The arrangement of species into five genera is supported. A key to the genera accepted in the Pleomassariaceae follows from the information obtained.

1. Ascospores small, mostly less than 30 µm long, obovoid, first-formed septum slightly submedian; ascomata erumpent superficial, applanate.................................2
1. Ascospores large, mostly longer than 30 µm............3
    2. Ascomata lichenized; ascospores several septate, wall smooth; asci cylindric...............*Eopyrenula*
    2. Ascomata nonlichenized; ascospores one septate, wall ornamented; asci cylindric or oblong clavate.... *Kirschsteiniothelia*
3. Ascospores obovoid, first-formed septum slightly or strongly submedian.........................*Splanchnonema*
3. Ascospores ellipsoid fusoid, first-formed septum median...............................................4
    4. Substrates various; asci cylindric...*Macrovalsaria*
    4. Substrates restricted; asci oblong clavate........ *Asteromassaria*

Three lichenized species of *Eopyrenula* were described and illustrated by Aptroot (1991). He recognized the type species, *E. leucoplaca* (Wallr.) R. C. Harris as restricted to Europe and added *E. intermedia* Coppins in Aptroot and *E. parvispora* R. C. Harris & Aptroot, both North American species. Both macro- and microconidia are produced in separate conidiomata in these species. Additional species are known, but the three listed above provide information that separates this genus in the Pleomassariaceae.

*Kirschsteiniothelia* was described and the species were arranged by Hawksworth (1985). Because of consistently small ascospores, *K. phileura* (Cooke & Peck) M. E. Barr, comb. nov. (basionym: *Sphaeria phileura* Cooke & Peck in Cooke & Ellis, Grevillea 5: 55. 1876) (Barr et al. 1986) is added to the genus. Hawksworth (1985) mentioned this taxon and concluded that it was a small form of *K. aethiops*. *Kirschsteiniothelia thujina* (Peck) D. Hawksw., with large ascospores, is transferred to *Splanchnonema* later in this article.

*Macrovalsaria* was described by Petrak (1961) for *M. leonensis* (Deighton) Petr. (*Valsaria leonensis* Deighton) with a suggested relationship to *Kirschsteiniella (i.e., Kirschsteiniothelia.)* Sivanesan (1975) made the combination *M. megalospora* to utilize the earlier epithet, uncovered two additional synonymous names and illustrated the species. This taxon usually forms large groups of ascomata that may be united two or three together under a common peridium. The uniseptate ascospores are ornamented by longitudinal slits in the wall, especially in the lower cell. This fungus is known on numerous substrates in the pantropics, from tropical Africa, India, Sri Lanka, Philippines, Guyana, and now Trinidad (St. Pat's Ridge, Arima Valley, 28 Apr 1957, H. Fleming, NY).

In *Asteromassaria* a relatively small number of species, restricted in substrate, having large, ellipsoid-fusoid, transversely septate ascospores whose first-formed septum is median, in oblong-clavate asci, group together, separately from the species having obovoid, transversely septate ascospores whose first-formed septum is slightly or strongly submedian. Ascomata may be immersed erumpent and sphaeroid to globose or erumpent superficial and applanate. The species are separated further on the bases of ascospore pigmentation, septation, wall ornamentation, and substrate. One newly described species and *A. berberidicola* (G. H. Otth) Boise (Boise 1985), are added to the species enumerated by Barr (1982).

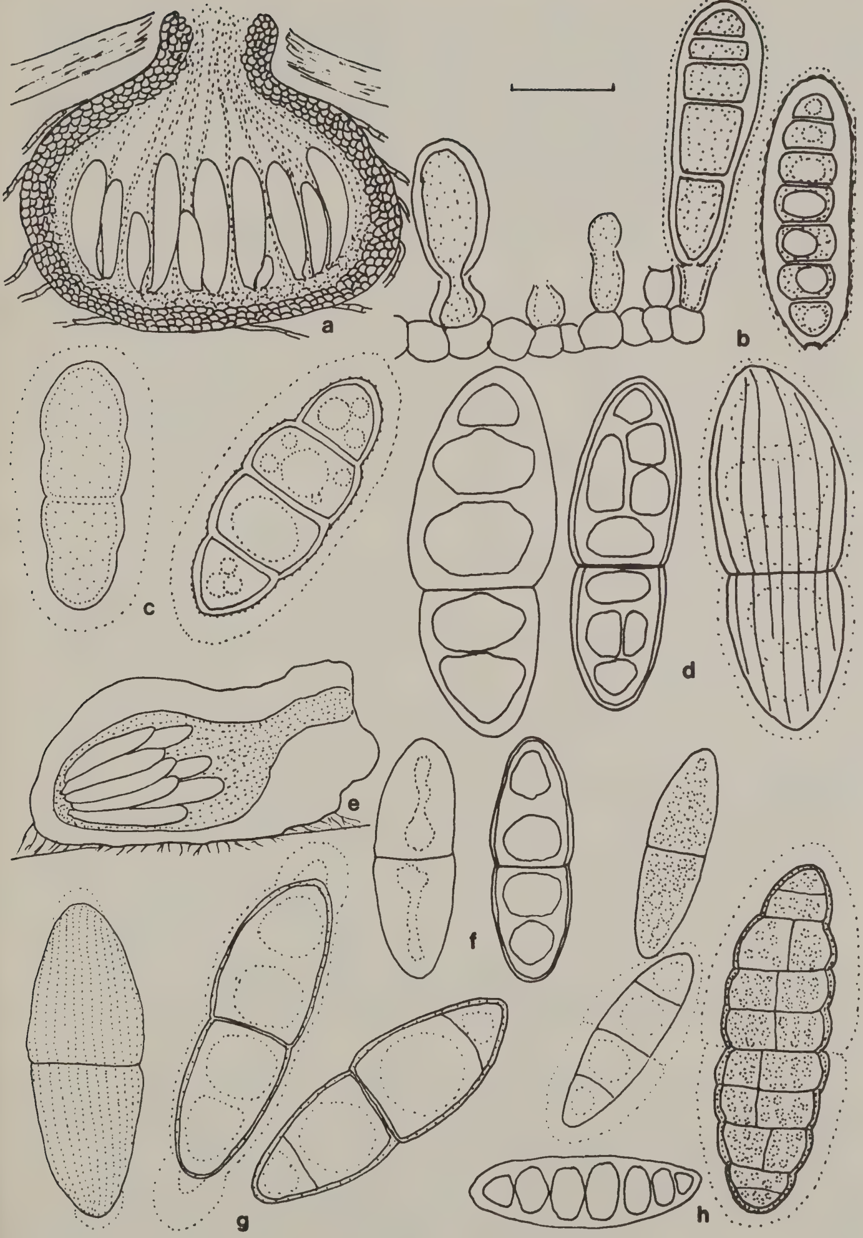
Key to species of *Asteromassaria* in North America

1. Ascomata immersed erumpent, sphaeroid to globose......2
1. Ascomata erumpent superficial, applanate..............6
   2. Ascospores 5-septate, wall smooth................3
   2. Ascospores 3-septate, wall ornamented...........4
3. Ascospores 50-72 x 15-23 µm; on *Morus*..*A. olivaceohirta*
3. Ascospores 56-72 x 18-26 µm, on *Sambucus*...*A. distincta*
   4. Second-formed septa near ends; on *Fagus*.......... *A. macrospora*
   4. Second-formed septa about median in each hemispore ..........................................5
5. Ascospores hyaline or lightly pigmented, 32-38 x 10-13 µm; on *Alnus*....................................*A. alni*
5. Ascospores (26-)28-35(-38) x 9-14 µm; on *Berberis*, *Salix*..................................*A. berberidicola*
   6. Ascospores 1-(3-)septate, brown, wall ornamented, 36-50 x 15-21 µm; on *Carya*................*A. seriata*
   6. Ascospores hyaline or lightly pigmented, wall smooth...........................................7
7. Ascospores 1-septate, 44-50.5 x 10-11 µm; on *Carya*..... *A. minor*
7. Ascospores 1-3-septate, 48-75 x 21-25.5 µm; on *Umbellularia*...........................*A. pulchra*

*Asteromassaria alni* M. E. Barr, sp. nov. Fig. a-c

Ascomata immersa gregaria sphaeroidea 600-700 µm lata vel 385-495 µm alta, papillae breves pallidae, peridia

Figs. a-h. Species of Pleomassariaceae. a-c. *Asteromassaria alni:* a, ascoma in vertical section, b, conidiogenous cells and conidia, c, ascospores. d. *Splanchnonema quercicola*, ascospores. e, f. *S. horizontale*: e, outline of ascoma in vertical section, f, ascospores. g. *S. striatulum*, ascospores. h. *S. holoschistum*, ascospores. Standard line = 100 µm for a and e, 10 µm for remainder of figures.


a
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brunneae 40-45 µm lata. Asci bitunicati 130-160 x 22-28 µm clavati basali. Pseudoparaphyses cellulosae. Ascosporae 32-38 x 10-13 µm hyaline vel brunnescens ellipsoideae 3-septatae biseriatae, tunica gelatinosa circumcinctae 2-3 µm vel 10 µm lata. Holotypus in ramis *Alni rugosae* (Du Roi) Spreng., "USA: Massachusetts: Horse Mt., Hatfield, 19 Mar 1972" a H. E. Ahles lectus, sub M. E. Barr n. 5988 in NY depositus.

Ascomata immersed, gregarious, sphaeroid, 600-700 µm wide, 385-495 µm high; apex short papillate, pallid; peridium dark brown, vinaceous toward apex, pseudoparenchymatous cells, 40-45 µm wide; bright brown hyphae from base and sides. Asci 130-160 x 22-28 µm, clavate. Pseudoparaphyses cellular, 1.5-2.5 µm wide. Ascospores 32-38 x 10-13 µm, hyaline becoming brown after discharge from ascus, ellipsoid, 3-septate, deeply constricted at septa; wall smooth, verruculose after discharge, gel coating 2-3 µm wide, expanding to 10 µm in water; one globule or several guttules in each cell; overlapping biseriate in the ascus.

Known from the type collection.

An associated anamorph has conidiomata similar in shape and structure to ascomata, immersed, up to 550 µm wide, 330-385 µm high, opening by wide pore; peridium dark brown, pseudoparenchymatous cells, up to 52 µm wide at sides, 40 µm wide at base and above, bright brown hyphae from sides; conidiophores lacking; conidiogenous cells lining locule, holoblastic, discrete, ampulliform, hyaline, thick walled. Conidia 32-36 x 11-12.5 µm, hyaline, brown after extrusion from locule, ellipsoid fusoid, 3-7-distoseptate; wall thick, verruculose, narrow gel coating when young; one globule per cell. This anamorph seems to be related to *Macrodiplodiopsis desmazieresii* (Mont.) Petr., the anamorph of *Splanchnonema platani* (Ces.) M. E. Barr, but lacks the complex wall structure of conidia, further, proliferation of conidiogenous cells was not observed. Sutton's (1980) valuable compendium did not provide a genus to accommodate the anamorph.

According to the pallid ascospores that tend to be pigmented only after discharge from the ascus, the species could be sought in *Massarina*, but it differs from species of that genus in stout-walled ascomata and asci, less numerous pseudoparaphyses, and the associated anamorph.

The largest grouping of species includes the type species of *Splanchnonema*, *Pleomassaria*, and *Stigmatomassaria*. The latter genus was already considered to be a synonym of *Splanchnonema* (Barr 1982). The three species have in common immersed sphaeroid ascomata restricted in substrate, oblong-clavate asci, large, usually brown, obovoid ascospores. The ascospores are transversely septate in *Splanchnonema foedans* (Fr.) Kuntze and *Stigmatomassaria pupula* (Fr.: Fr.) Munk, muriform in *P.*

*siparia* (Berk. & Broome) Sacc.. Because of the obvious similarities in all other characters, I now recognize a single genus rather than two. Among the other species, ascomata may also be erumpent superficial and applanate, asci may be cylindric, and the ascospores may be hyaline or lightly pigmented, one or several transversely septate or muriform, wall smooth or ornamented. These variations permit separation of the North American species.

Key to species of *Splanchnonema* in North America

1. Ascomata immersed erumpent, sphaeroid to globose......2

1. Ascomata erumpent superficial, applanate............21

2. First-formed septum of ascospores strongly submedian........................................3

2. First-formed septum of ascospores slightly submedian........................................14

3. Ascospores transversely septate, wall ornamented......4

3. Ascospores muriform, wall ornamented or smooth.......10

4. Ascospores usually remaining 1-septate, 33-55 x 12-20 µm; on *Tilia*.....................*S. ampullaceum*

4. Ascospores usually developing one or more septa in each hemispore.................................5

5. Ascospores developing one (two) septa in both upper and lower hemispores......................................6

5. Ascospores developing two to four septa in upper hemispore, (none) one (two) in lower...................8

6. Ascospores (26-)32-42(-50) x 13-16.5 µm; on *Fagus*. *S. loricatum*

6. Ascospores 38-60 µm long.......................7

7. Ascospores 38-55 x 12-17.5 µm; on *Ulmus*, *Celtis*........ *S. foedans*

7. Ascospores 45-60 x 14-20 µm; on *Magnolia*.............. *S. clandestinum*

8. Ascospore wall ornamentation forming longitudinal striae, 45-55(-70) x 16-22 µm; on *Quercus*........... *S. quercicola*

8. Ascospore wall ornamentation not forming longitudinal striae.....................................9

9. Ascospores 40-77 x 13-17.5 µm; on *Platanus*...*S. platani*

9. Ascospores 45-67 x 15-18 µm; on *Betula*.........*S. argus*

10. Ascospores pallid or lightly pigmented, 104-140 x 24-36 µm, up to 35 and 2-3-septate, wall smooth, usually solitary in the ascus; on *Betula*............ *S. monospermum*

10. Ascospores brown, wall ornamented.............11

11. Asci cylindric; ascospores uniseriate, 38-48 x 11-16.5 µm, 11-15- and 2-3-septate; on *Ulmus*...........*S. ulmicola*

11. Asci oblong clavate; ascospores biseriate..........12

12. Ascospores (30-)35-52 x 13-20 µm, 6-9- and 1-3-septate; on *Carpinus*.......................*S. carpini*

12. Ascospores (32-)50-70 µm long.................13

13. Ascospores (32-)50-64 x (10-)15-18) µm, 5-7-(8-) and 1-septate; on *Acer*..........................*S. acericola*

13. Ascospores 40-70(-90) x 13-16(-21) µm, 3-7(-8) and 1-septate; on *Betula*............................*S. siparium*

14. Ascospores transversely septate...............15

14. Ascospores muriform...........................17

15. Ascospores 40-56 x 12-15 µm, 1-3-septate, wall ornamentation forming longitudinal striae; on *Sambucus*.... *S. striatulum*

15. Ascospores developing additional septa, wall ornamentation not forming longitudinal striae..................16

16. Ascospores 38-58 x 14-20 µm, 3-5-(6-)septate; on *Acer*...................................*S. pupulum*

16. Ascospores (17-)36-56 x 10-14 µm, 7-8-septate; on wood..........................*S. britzelmayerianum*

17. Asci cylindric, ascospores uniseriate..............18

17. Asci oblong clavate, ascospores biseriate...........19

18. Ascospores 30-42 x 14-18(-20) µm, 7-9- and 2-3-septate; on *Arbutus*.........................*S. arbuti*

18. Ascospores 32-46 x 12-15 µm, 7-11- and 1-(2-) septate; on *Salix*, *Populus*...............*S. hesperium*

19. Ascospores 65-80(-94) x 20-26 µm, 9-11- and 1-3-septate; on *Magnolia*...........................*S. maximum*

19. Ascospores 35-52 x 11-16 µm........................20

20. Ascomata 250-450 µm wide; ascospores 5-9- and 1-2-septate; on *Vaccinium*..................*S. vaccinii*

20. Ascomata 500-900 µm wide; ascospores 3-7-(10-) and 1-septate; on *Alnus*..............*S. holoschistum*

21. First-formed and only septum of ascospores strongly submedian.........................................22

21. First-formed septum of ascospores slightly submedian ....................................................24

22. Ascospore wall smooth, 38-52(-60) x 16-23 µm; on *Carya*...................................*S. hicorium*

22. Ascospore wall ornamented.......................23

23. Ascospores 32-42 x 13-17 µm; on *Quercus*..*S. melanterum*

23. Ascospores 48-60(-65) x (15.5-)18-24 µm; on *Betula*.... *S. scoriadeum*

24. Ascospores remaining one-septate, wall smooth or nearly so.......................................25

24. Ascospores three or more septate at maturity...26

25. Ascomata horizontal; ascospores 33-37.5 x (7.5-)10-12 µm; on *Pinus*..............................*S. horizontale*

25. Ascomata upright; ascospores (29-)35-50(-55) x 12-17 (19.5) µm; on *Thuja*, *Abies*....................*S. thujinum*

26. Ascospores 3-septate, 33-36 x 11-14 µm, wall smooth; on *Platanus*.....................*S. semitectum*

26. Ascospores 3-7-septate, (22-)30-46 x (7-)9-11 µm, wall ornamented; on *Platanus*...........*S. sporadicum*

*Splanchnonema arbuti* M. E. Barr and *S. vaccinii* M. E. Barr were described recently from ericaceous substrates in western North America (Barr 1993). Some new combinations and descriptions of new species follow. Descriptions and illustrations are found in Barr (1982, 1990), Crivelli (1983) or Boise (1985).

*Splanchnonema carpini* (Fuckel) M. E. Barr, comb. nov. Bas.: *Massaria carpini* Fuckel, Jahrb. Nassauischen Ver. Naturk. 23-24: 153. 1870.

*Splanchnonema hesperium* (M. E. Barr) M. E. Barr, comb. nov. Bas.: *Pleomassaria hesperia* M. E. Barr, Mem. New York Bot. Garden 62: 15. 1990.

*Splanchnonema holoschistum* (Berk. & Broome) M. E. Barr, comb. nov. Fig. h. Bas.: *Sphaeria holoschista* Berk. & Broome, Ann. & Mag. Nat. Hist. ser. 3, 7: 453. 1861.

Described by Crivelli (1983), this species on *Alnus* is now known from Canada (British Columbia: Sidney, 1 Jul 1991, M. E. Barr 7641, DAOM).

*Splanchnonema horizontale* M. E. Barr, sp. nov. Fig. e, f

Ascomata superficialia horizontalia 350 µm lata vel 220 µm alta, papillae laterales circa 120 µm lata et alta, peridia brunnea basin versus 15 µm vel apicem versus 30-45 µm. Asci bitunicati 120-132 x 16.5-22 µm clavati vel oblongi inflati horizontales. Pseudoparaphyses cellulosae. Ascosporae 33-37.5 x (7.5-)10-12 µm brunneae obovoideae uniseptatae biseriatae. Holotypus in cortice *Pini rigidae* Mill., "USA: West Virginia: Fayette Co., Nuttallberg, Jun 1894" a L. W. Nuttall lectus, sub N.A.F. 3113 "*Amphispharia pinicola* Rehm" ex MASS in NY et isotypus in FH depositus.

Ascomata superficial in and on fibrous periderm, horizontal, ca. 350 µm wide, 220 µm high, apex lateral, short and wide, ca. 120 µm, ostiole stuffed with cells; peridium dark brown, small pseudoparenchymatous to somewhat compressed cells, ca. 15 µm near periderm, 30-45 µm wide above, dark brown hyphae into periderm cells. Asci 120-132 x 16.5-22 µm, clavate or inflated below mid region, horizontal in centrum. Pseudoparaphyses narrow cellular. Ascospores 33-37.5 x (7.5-)10-12 µm, light to dark brown, obovoid, 1-septate, slightly submedian, slightly constricted, two distoseptate globules in each hemispore; wall smooth or finely verruculose; overlapping biseriate in the ascus.

Known from type locality.

This species is considerably larger than Rehm's *Amphisphaeria pinicola (A. betulina f. pinicola* Rehm), which Hawksworth (1985) includes in the synonymy of *Kirschsteiniothelia aethiops*. M. Sherwood had annotated the FH copy as *Microthelia biformis [= Anisomeridium biforme* (Borrer) R.C. Harris, Acrocordiaceae]. *Splanchnonema horizontale* is close to *S. thujina* in ascus and ascospore shapes, although ascospore sizes are smaller, and it differs strongly by the position of ascomata.

*Splanchnonema maximum* (Ellis & Everh.) M. E. Barr, comb. nov. Bas.: *Pleomassaria maxima* Ellis & Everh. Bull. Torrey Bot. Club 25: 505. 1898.

*Splanchnonema monospermum* (Peck) M. E. Barr, comb. nov. Bas.: *Sphaeria monosperma* Peck, Rep. New York State Mus. 28: 79. (for 1874) 1876.

*Splanchnonema quercicola* M. E. Barr, sp. nov. Fig. d

Ascomata immersa gregaria sphaeroidea vel globosa 500-600 µm lata vel 440-550 µm alta, papillae breves, peridia badia 30-60 µm lata. Asci bitunicati 150-175 x 30-40 µm clavati basali. Pseudoparaphyses cellulosae. Ascosporae 45-55(-70) x 16-22 µm brunneae obovoideae 4-6-septatae biseriatae, tunica gelatinosa circumcinctae 2-3 µm lata. Holotypus in ramulis *Querci*, "USA: Arizona: Pima Co., Santa Catalina Mts., 2 Aug 1980" a M. E. Barr n. 6797 lectus in NY depositus.

Ascomata immersed, gregarious, sphaeroid to globose, 500-600 µm wide, 440-550 µm high, apex obtuse, ostiole stuffed with pseudoparaphyses; peridium dark reddish brown, small pseudoparenchymatous cells, 30-60 µm wide. Asci 150-175 x 30-40 µm, clavate. Pseudoparaphyses narrow cellular, densely branched and interwoven above asci. Ascospores 45-55(-70) x 16-22 µm, dark brown, obovoid, first-formed septum submedian, euseptate, constricted, upper hemispore 2-3-distoseptate, lower hemispore 1-2-distoseptate, occasional longitudinal septum in one or two cells; wall thick, longitudinal striae apparently within wall, gel coating 2-3 µm wide; homogeneous; biseriate in the ascus.

Known from type collection.

Conidiophores of the presumed anamorph, *Helminthosporium* cfr. *velutinum* Link ex Gray had developed from apices of ascomata, and produced typical conidia. *Splanchnonema quercicola* was compared to the description and illustrations of *S. kalakadense* Subram. & Sekar, which was linked in culture to *H. velutinum* (Subramanian and Sekar 1987). The Indian species, on unknown woody substrate, differs in larger ascomata, narrower asci, and smaller ascospores, 26-32 x 10-14 µm, that usually remain uniseptate and are smooth walled.

*Splanchnonema siparium* (Berk. & Broome) M. E. Barr, comb. nov. Bas.: *Sphaeria siparia* Berk. & Broome, Ann. & Mag. Nat. Hist., ser. 2, 9: 321. 1852.

*Splanchnonema striatulum* M. E. Barr, sp. nov. Fig. g

Ascomata immersa gregaria sphaeroidea 495 um lata vel 385 µm alta, papillae minutae, peridia brunneae basin versus 10-20 µm vel apicem versus 20-35 µm. Asci bitunicati 100-150 x 20-35 µm oblongi clavati basali. Pseudoparaphyses cellulosae. Ascosporae 40-56 x 12-15 µm brunneae obovoideae 1-(3-)septatae striatulatae biseriatae, tunica gelatinosa circumcinctae. Holotypus in ramis *Sambuci callicarpae* Greene, "USA: California: Marin Co., Muir Woods, 7 Dec 1971" a M. E. Barr n. 5950c lectus in NY depositus.

Ascomata immersed, gregarious, sphaeroid, up to 495 µm wide, 385 µm high, apex with minute pallid papilla; peridium dark brown, small pseudoparenchymatous cells, ca. 10-20 µm wide at base and lower sides, 20-35 µm wide at upper sides; abundant brown hyphae from peridium into substrate. Asci 100-150 x 20-35 µm, oblong clavate. Pseudoparaphyses cellular, 3-5 µm wide. Ascospores 40-56 x 12-15 µm, brown, obovoid, 1-(3-)septate, constricted at the slightly submedian first-formed septum; wall thick, foveolate, foveolae arranged in delicate longitudinal striae, gel coating narrow laterally, enlarged over ends as pulvinate appendages; one or two globules per cell; overlapping biseriate in the ascus.

Known from type collection.

*Splanchnonema striatulum* is related most closely to *S. pupulum* and *S. britzelmayerianum* (Rehm) Boise; it differs especially by ascospores that contain fewer septa and have a delicately striate wall.

*Splanchnonema thujinum* (Peck) M. E. Barr, comb. nov. Bas.: *Sphaeria thujina* Peck, Rep. New York State Mus. 27: 110. (for 1873) 1875. Descriptions and illustrations are provided in Pomerleau and Etheridge (1962) and Hawksworth (1985).

*Splanchnonema ulmicola* (Fuckel) M. E. Barr, comb. nov. Bas.: *Cucurbitaria ulmicola* Fuckel, Jahrb. Nassauischen Ver. Naturk. 23-24: 172. 1870.

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# ADDITIONAL NEW TAXA AND A NEW REPORT OF PERTUSARIA (LICHENISED ASCOMYCOTINA) FROM AUSTRALIA

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ABSTRACT: The species *Pertusaria alboaspera* Archer & Elix, *Pertusaria flavoisidiata* Archer & Elix, *Pertusaria subventosa* Malme var. *deficiens* Archer & Elix, *Pertusaria subventosa* Malme var. *hypothamnolica* Archer & Elix, *Pertusaria xanthonaria* Archer and Elix are described as new; *Pertusaria melaleucoides* Müll.Arg. [syn. *Pertusaria atropunctata* Archer] is reported as new to Australia.

## INTRODUCTION

A number of new species in the lichen genus *Pertusaria* have recently been described from Australia (Kantvilas 1990, Archer 1991, 1991a, 1992, Archer & Elix 1992) and an examination of further Australian specimens, including recent collections made in New South Wales and the Northern Territory, has shown the presence of additional undescribed taxa which are reported here. The techniques used for the examination of specimens have been described previously (Archer 1991); the chemistry of the majority of the specimens examined was confirmed by liquid chromatography (Elix & Venables 1993). The spore descriptions follow the nomenclature of Dibben (Dibben 1980: 10). The figures illustrate holotypes and the type specimens cited have been seen unless noted otherwise.

**Pertusaria alboaspera** Archer & Elix sp. nov. Fig. 1

Thallus flavo-albus, tenuis, areolatus et rimosus, superficies laevis et hebeta, isidiis et sorediis destitutus; corticola; apothecia verruciformia, thallo concoloria, numerosa, interdum confluentia, hemisphaerica vel plano-hemisphaerica, basibus non constrictis, 0.5-1.0 mm diam.; ostiola inconspicua, hinnulea, translucida, in verrucas singulas; sporae 8nae, biseriatae, ellipsoideae, laeves, 90-100 µm longae, 30-37 µm latae.

Thallus lichexanthone, acida 2,2'-di-*O*-methylstenosporica et stictica continens.

*Type*: Australia, New South Wales, Border Ranges National Park, by side of Sawpit Creek, ca. 30 km NNW of Kyogle, 28°22'S, 152°50'E, on fallen branch, alt. *ca.* 200 m, *A. Archer P422,* 30.viii.1992; NSW-holotype.

*Thallus* pale yellowish-white, thin, areolate and cracked, surface smooth and dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, concolorous with the thallus, numerous, sometimes confluent, hemispherical to flattened hemispherical, not constricted at the base, 0.5-1.0 mm diam.; ostioles inconspicuous, pale, translucent, 1 per verruca; *spores* 8 per ascus, biseriate, ellipsoid, smooth, 90-100 µm long, 30-37 µm wide.

*Chemistry*: K-, KC-, C-, Pd-; lichexanthone (major), 2,2'di-*O*-methylstenosporic acid (major), stictic acid (major) and constictic acid (minor ).

*Pertusaria alboaspera* is characterised by the eight biseriate spores and the presence of lichexanthone, 2,2'-di-*O*-methylstenosporic acid and stictic acid. This chemistry is also found in two of the three syntypes of *Pertusaria verruculifera* Vainio [TUR-V 6750 and 6751] described from Brazil (Vainio 1890:110) but that species differs from *Pertusaria alboaspra* in having eight uniseriate spores which are 50-67 µm long and in containing constictic acid as an additional major component. The third syntype of *Pertusaria verruculifera* [TUR-V 6752] is sterile and contains haemathamnolic acid as the major lichen compound. The combination of spore number and arrangement, and chemistry distinguishes the new species from all other Australian *Pertusaria* taxa.

The epithet "alboaspera", white-rough, refers to the off-white thallus with many small verrucae. The new species is known only from the type specimen.

**Pertusaria flavoisidiata** Archer & Elix sp. nov. Fig. 2

Thallus stramineus, tenuis, superficies laevis et hebeta, isidiata sed sorediis destitutus; corticola; isidia dispersa, inconspicua, 0.2-0.3 mm alta, 0.05 mm diam.; apothecia et sporae non vidi.

Thallus acida thiophaninica, stictica et constictica continens.

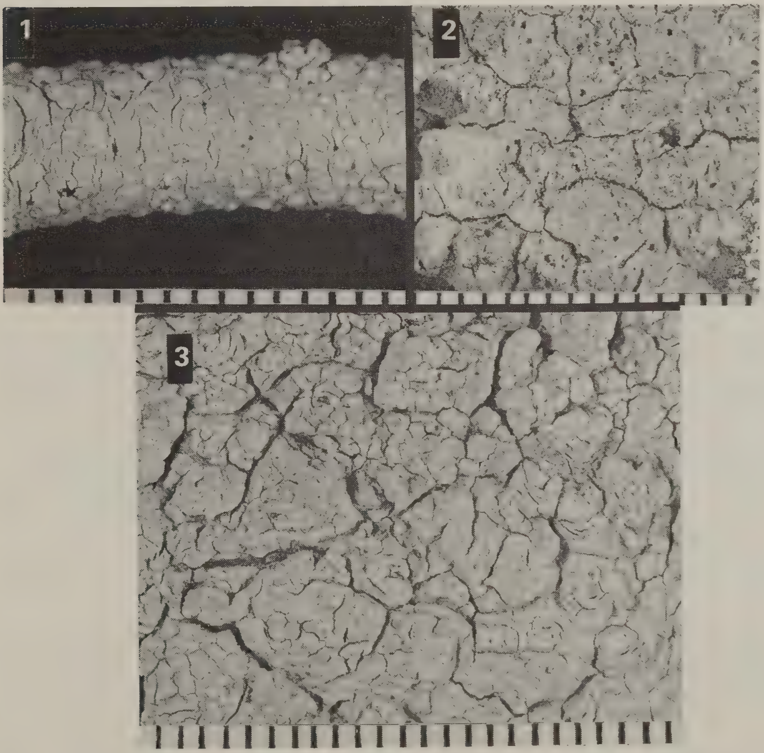
*Type*: Australia, Northern Territory, Wangi Falls, Litchfield Park, 40 km SW of Batchelor, 13°10'S, 130°41'E, alt. 60 m, on tree trunk in open woodland, *J.A. Elix 27615, H.T. Lumbsch & H. Streimann*, 3.vii.1991; ANUC-holotype.

*Thallus* dull yellow, thin, surface smooth and dull, isidiate, lacking soredia, corticolous; *isidia* scattered, inconspicuous, simple, 0.2-0.3 mm tall, 0.05 mm diam.; *apothecia* and *spores* not seen.

*Chemistry*: K-, KC+ orange, C+ weak orange, Pd-; thiophaninic acid (major), stictic acid (major), constictic (major), cryptostictic acid (trace), menegazziac acid (trace -minor), 2-chloro-6-*O*-methylnorlichexanthone (minor) and 4-chloro-6-*O*-methylnorlichexanthone (trace).

*Specimens examined*
Northern Territory, type locality, *J.A. Elix 27616, 27624, H.T. Lumbsch & H. Streimann*, 3.vii.1992 (ANUC).

*Pertusaria flavoisidiata* is characterised by the thin, dull yellow thallus with inconspicuous isidia. It is distinguished from isidiate forms of the chemically similar *Pertusaria xanthoplaca* Müll.Arg. by the dull yellow colour, the absence of verrucae and the preferred substrate, wood.



Figs. 1-3. New *Pertusaria* species. 1. *Pertusaria alboaspera*, 2. *Pertusaria flavoisidiata*, 3. *Pertusaria xanthonaria*

*Pertusaria xanthoplaca* occurs only on rock. The new species is known only from the three specimens from the type locality.
The epithet "flavoisidiata" refers to the yellow isidia.

**Pertusaria subventosa** Malme var. **deficiens** Archer & Elix var. nov.

Thallus sicut *Pertusaria subventosa* Malme sed acidum thamnolicum deficiens.
Thallus lichexanthone et acidum picrolichenicum continens.

*Type*: Australia, Queensland, Great Dividing Range, Hughenden-Townsville Highway, 28 km SW of Pentland, 20°43'S, 145°14'E, alt. 460 m, on sandstone, *J.A. Elix 20753*, 25.vi.1986; ANUC-holotype.

Thallus off-white to greyish-white, moderately thick, areolate and cracked, surface smooth, sorediate, lacking isidia, saxicolous; soralia white, conspicuous, becoming numerous away from the margin, subsherical, sometimes becoming becoming slightly stipitate; apothecia and spores not seen.

Chemistry: K-, KC+ violet, C-, Pd-; lichexanthone, picrolichenic and hyperpicrolichenic acids.

*Specimens examined*
Queensland: Eungella National Park, Mt. Dalrymple, NW of Mackay, 21°02'S, 148°38'E, alt. 1240 m, on granite outcrops, *G. Rambold 4700*, 20.ii.1986 (M); 12 km W of Charters Towers, 20°07'S, 146°10'E, alt. 340 m, on rocky outcrop beside Flinders Highway, *G. Rambold 4700*, 23.ii.1986 (M); Crystal Creek National Park, Little Crystal Creek, 19°01'S, 146°16'E, alt. 365 m, on boulders beside Falls, *G. Rambold 4804*, 25.ii.1986 (M); Porcupine Creek Gorge, 16 km NNE of Hughenden, 20°18'S, 144°26'E, alt. 450 m, on semi-shaded boulder beside stream, *H. Streimann 37315*, 26.vi.1986 (CBG 9202223); Bellenden Ker Range, Mulgrave River, on siliceous rock, *H.T. Lumbsch 5405c*, 13.viii.1987 (herb. LUMBSCH); Mistake Mountains, near Brisbane, 28°13's, 152°31'E, *H.T. Lumbsch 5709c*, 29.ix.1987 (herb. LUMBSCH); ibid., *H.T.Lumbsch 5699b*, (herb. LUMBSCH, NSW); Lynd Junction, Charters Towers Road, 26 km WSW of Greenvale, 18°59'S, 144°41'E, alt. 620 m, *H. Streimann 46871*, 20.xii.1990 (CBG ). New South Wales: Track to Pigeon House Mountain, 15 km W of Ulladulla, 450 m, 29.ix.1977, *J.A. Elix 3908* (ANUC).

The new variety *deficiens* resembles variety *subventosa* Malme (Malme 1936) but is distinguished from that species by the absence of thamnolic acid. Unlike var. *subventosa*, var. *deficiens* has not been found with apothecia and spores. *Pertusaria ventosa* Malme, from Brazil, also contains lichexanthone and picrolichenic acid but this species is esorediate (see Table 1) and has fertile disciform apothecia .

TABLE 1

SAXICOLOUS *PERTUSARIA* WITH LICHEXANTHONE AND β-ORCINOL meta-DEPSIDES

| | picrolichenic acid | thamnolic acid | hypothamnolic acid | soralia |
|---|---|---|---|---|
| *P. subventosa* Malme | + | + | | + |
| *P. subventosa* Malme var. *hypothamnolica* | + | | + | + |
| *P. subventosa* Malme var. *deficiens* | + | | | + |
| *P. ventosa* Malme | + | | | |
| *P. amaroides* H. Magn. | | | + | + |

**Pertusaria subventosa** Malme var. **hypothamnolica** Archer & Elix var. nov

Thallus sicut *Pertusaria subventosa* sed acidum hypothamnolicum vice acidum thamnolicum.
Thallus lichexanthone, acida picrolichenica et hypothamnolica continens.

*Type*: Australia, Queensland, between Breakneck and Quandong Creek, 24 km WSW of Proserpine, 20°29's, 148°22'E, alt. 150 m, on basalt rocks, *J.A. Elix 21160*, 2.vii.1986; ANUC-holotype.

*Chemistry:* K+ violet, KC+ violet, C-, Pd-; lichexanthone, picrolichenic and hypothamnolic acids

*Specimens examined*
PAPUA NEW GUINEA, Central Province, Varirata National Park, Sogeri, 22 km ENE of Port Moresby, 9°25'S, 147°21'E, alt. 600 m, *H.Streimann 14453*, 5.ii.1981 (CBG 8113359).
AUSTRALIA, Queensland, Mt. Elliot National Park, 30 km SE of Townsville, 19°28'S, 147°00'E, alt. 220 m, *G. Rambold 4731*, 24.ii.1986 (M); Mt. Farrenden, 26 km SSW of Charters Towers, 20°19'S, 146°13'E, alt. 450 m, *H.Streimann* 37239, 22.vi.1986 (CBG 9003896); Glasshouse Mtns., SSW of Tibrogargan Mtns., 26°57'S, 152°56'E, alt. 150 m, on rhyolithe outcrop, *J.Hafellner 15691 p.p.*, 19.viii.1986 (GZU); ibid., ca. 3 km S of Crookneck Mtns., 26°57'S, 152°56'E, alt. 100 m, *J.Hafellner 15814*, 26.vii.1986 (GZU);

Rainbow Beach Road, W of Cooloola National Park, 12.5 km S of Tin Can Bay, 26°02'S, 153°02'E, alt. 100 m, on granite rocks, *J.A. Elix 22783* p.p., 1.vii.1989 (ANUC).

The new variety *hypothamnolica* resembles variety *subventosa* Malme but is distinguished from that species by the presence of hypothamnolic acid in place of thamnolic acid. *Pertusaria amaroides* H. Magn. (Magnusson 1950: 214) from Brazil, also contains lichexanthone and hypothamnolic acid but this species lacks picrolichenic acid (see Table 1).

**Pertusaria xanthonaria** Archer & Elix sp. nov. Fig. 3

Thallus flavidus, areolatus et rimosus, superficies laevis et hebeta, isidiis et sorediis destitutus; corticola; apothecia verruciformia, numerosa, conferta, raro confluentia, thallo concoloria, plano-hemisphaerica, 0.6-1.0 mm diam.; ostiola conspicua, translucida, in verucas singulas, 0.2-0.3(-0.7) mm diam.; sporae 2nae, ellipsoideae, laeves, 110-130 μm longae, 30-40 μm latae. Thallus 2,4-dichlorolichexanthone, 2,5-dichlorolichexanthone et 2,4,5-trichlorolichexanthone continens.

*Type*: Australia, New South Wales, by side of Evans River, ca. 3 km SW of Evans Head, 29°06'S, 153°24'E, alt. 2m, on *Avicennia*, *A.W. Archer P 471*, 12.ix.1992; NSW-holotype; ANUC, CBG, MEL-isotypes.

*Thallus* pale yellow, areolate and cracked, surface smooth and dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, numerous, crowded, rarely confluent, concolorous with the thallus, flattened hemispherical, 0.6-1 mm diam.; ostioles conspicuous, translucent, one per verruca, 0.2-0.5(-0.7) mm diam.; *spores* 2 per ascus, ellipsoid, smooth, 110-130 μm long, 30-40 μm wide.

Chemistry: K-, KC+ weak yellow, C-, Pd-; 2,4-dichlorolichexanthone (major), 2,5-dichlorolichexanthone (major), 2,4,5-trichlorolichexanthone (major) with 2-chlorolichexanthone (minor) and 4,5-dichlorolichexanthone (trace).

*Specimens examined*
Australia, New South Wales, type locality, on *Avicennia*, *A.W. Archer P 391, P 392, P 462, P 463*, 12.ix.1992 (NSW).

*Pertusaria xanthonaria* is characterised by verrucae with conspicuous translucent ostioles, the two-spored asci and the presence of polychlorolichexanthones. It resembles *Pertusaria schizostomella* Müll.Arg., a second Australian species with translucent ostioles and two-spored asci which is also found on mangroves but this species contains thiophaninic and stictic acids. *Pertusaria xanthonaria* occurs on mangroves in coastal northern New South Wales; it was common at the type locality.

The epithet "xanthonaria", xanthone + aria, possessing xanthones, refers to the presence of xanthones as the sole class of lichen compounds present in the thallus and verrucae.

NEW REPORT

**Pertusaria melaleucoides** Müll.Arg. *Flora* 67: 284 (1884).

*Type*: New Zealand, sin. loc., *C. Knight s.n.*, 1883; G-holotype [not seen, fide Galloway].

*Pertusaria galactina* Zahlbr. *Denkschr. Akad. Wiss. Wien math.-naturwiss. Kl.* 104: 332 (1941).

Type: New Zealand, North Island, forest remnant near Fielding, ca. 150 m, on *Melicystus ramiflorus*, *H.H.Allan s.n.*, Dec 1933 ; W-holotype ZA 460.

*Pertusaria atroalba* (sic) Zahlbr., nom. nud. in sched.

Specimen labelled by Zahlbruckner:
New Zealand, North Island, Rangitoto Island, near Islington Bay, 36°47'S, 174°52'E, on *Avicennia resinifera*, *H.H.Allan s.n.*, 24.viii.1933 (AK 18997)

*Pertusaria atropunctata* Archer, *Mycotaxon* 41: 224 (1991). Fig. 1, p. 229.

Type: Australia, New South Wales, Buckenbowra River Estuary, 7.5 km W of Batemans Bay, 35°42'S, 150°06'E, on *Avicennia marina*, *J.A. Elix 11004*, 29.v.1983; holotype ANUC.

Thallus greyish-white, areolate and cracked, surface dull, lacking soredia and isidia, corticolous; apothecia verruciform, flattened hemispherical to immersed, concolorous with the thallus, 0.5-1 mm diam.; ostioles conspicuous, black, 1-4 per verruca, fusing to form an irregular black, pseudolecideine disc, 0.3-0.6 mm diam; spores 2 per ascus, ellipsoid, smooth, (80-) 100-125 µm long, 30-40 µm wide.

Chemistry: K-, KC-, C-, Pd-; no lichen compounds detected.

*Specimens examined*:
Australia, New South Wales, Buckenbowra River estuary, on *Avicennia marina*, *K. Kalb 18757*, *18901*, 4.vi.1988 (herb. KALB); Narrawallee Inlet, ca. 55 km NNE of Batemans Bay, 35°18'S, 150°28'E, on *Avicennia marina*, *A. Archer P280*, 28.iii.1992 (CBG, NSW).

*Pertusaria melaleucoides* is characterised by conspicuous black ostioles, asci with two spores and the absence of lichen compounds. It usually occurs on mangroves in both Australia and New Zealand. It is one of a number of *Pertusaria* taxa from eastern coastal Australia which have recently been found in New Zealand and these shared taxa will be discussed in a later paper. *Pertusaria "atroalba*" (*nom.nud.*) is an unpublished name used by Zahlbruckner; the specimen thus labelled is distinct from his New Zealand species *Pertusaria alboatra* (Zahlbruckner 1941) which also has conspicuous black ostioles and two spores per ascus (rarely three) but contains thiophaninic acid.

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# ISOZYME AND PROTEIN PATTERNS OF ENDOPHYTIC AND DISEASE SYNDROME ASSOCIATED ISOLATES OF MELANCONIUM APIOCARPUM AND MELANCONIUM MARGINALE COLLECTED FROM ALDER

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## ABSTRACT

Isozyme and protein patterns of five of each Disease Syndrome Associated (DSA) isolates and Symptomless Endophytes (SE) of *Melanconium apiocarpum* as well as 10 DSA *Melanconium marginale* isolates from different species of alder were determined by polyacrylamide gel electrophoresis. Seven of the 13 enzyme systems tested produced positive activities: acid phosphatase, β-glucosidase, malate dehydrogenase, phosphoglucomutase, β-esterase, peroxidase and polyphenoloxidase, but only the latter three enzyme systems allowed differentiation between *M. apiocarpum* (SE and DSA) and *M. marginale* isolates. In addition, *M. marginale* isolates differed from *M. apiocarpum* in their non-SDS electrophoretic protein banding patterns, protein contents, yield of acetone powder and relative virulence on apple fruits. None of the methods used showed differences between SE and DSA isolates of *M. apiocarpum.* The use of β-esterase, peroxidase and polyphenoloxidase enzyme systems as potential biochemical markers is proposed as a taxonomic tool to differentiate *M. apiocarpum* (SE and DSA) from *M. marginale* isolates. These findings imply that DSA and SE isolates of *M. apiocarpum* are similar if not identical. Future research is directed toward manipulation of the SE isolates and their hosts (*Alnus* spp.), to promote them to pathogenic phase so that they can function as biological control agents (mycoherbicides) for control of alder on reforestation sites.

## Introduction

A major problem associated with forest renewal efforts is that industrially valuable conifers planted on forest renewal sites must compete with unwanted vegetation or forest weeds. Examples of such weeds are red alder (*Alnus rubra* Bong.), sitka alder (*Alnus viridis* (Chaix) DC.) and thinleaf alder (*Alnus tenuifolia* Nutt.) which are deciduous trees indigenous to the Pacific coast mesothermal forest region of British Columbia (B.C.), Canada and the United States, and which often grow in pure stands as early occupants on cleared land (Haeussler and Coates 1986).

Traditionally, chemical herbicides and burning have been used to control the growth of forest weeds, but increasing public opposition to these methods has caused much research to be directed toward development of biological control agents or mycoherbicides (Dorworth 1990, Wall 1990, Wall and Shamoun 1990, Wall *et al.* 1992, Winder and Shamoun 1992). Biochemical characterization of biocontrol agents is required to satisfy the requirements for registration and labelling of the mycoherbicides (Byrne 1991, Shamoun *et al.* 1991c).

So far, the search for candidate biocontrol agents has been limited to fungi from diseased plants. There exists also a distinctive community of fungi, called endophytes, that live within apparently healthy plants; disease symptoms are not manifested during part or all of the life cycles of these endophytic fungi (Carroll and Carroll 1978, Sieber *et al.* 1991a). Some are potential pathogens, whereas others may be mutualistic symbionts.

*Melanconium apiocarpum* Link (Synonym: *Melanconium sphaeroideum* Link: Fr., anamorph of *Melanconis alni* Tul. & C. Tul.) is known to occur in *Alnus rubra* either as a symptomless endophyte (SE) or as a disease syndrome associated (DSA) microorganism associated with cankers and necrosis of stems and twigs (Sieber *et al.* 1989). Sieber *et al.* (1989) reported that *M. apiocarpum* was isolated from 2% of twigs of symptomless red alder in B.C. It was, however, the only species of *Melanconium* detected as SE in 800 tissue samples. By contrast, among DSA fungi of *A. rubra* in coastal B.C., 55% of the *Melanconium* spp. were *M. marginale* Wehmeyer (anamorph of *Melanconis marginalis* (Peck) Wehmeyer) and 45% were *M. apiocarpum* (Dorworth 1990). Currently, these fungi are under intensive investigation at the Pacific Forestry Centre to assess their usefulness as potential biocontrol agents (mycoherbicides) for red and sitka alder in B.C.

The electrophoretic technique for analysis of proteins and enzymes has been used extensively in fungal taxonomy in the last decade (Franke 1973, Shecter 1973, Snider 1973, Stipes *et al.* 1982, Micales *et al.* 1986). To a lesser extent, electrophoresis of isozymes has also been utilized to differentiate and characterize strains, formae speciales, or isolates of organisms varying in pathogenicity (Alfenas *et al.* 1984, Bernier *et al.* 1983, Morrison *et al.* 1985, Shamoun 1991, Shamoun *et al.* 1991a, 1991b, 1991c).

The objectives of this study were to determine if non-SDS protein and isozyme patterns could be used as biochemical markers to: (1) differentiate between

SE and DSA isolates of *Melanconium apiocarpum*; and (2) differentiate and clarify the taxonomic relationships between *Melanconium apiocarpum* and *Melanconium marginale* isolates collected from red and sitka alder. A single isolate of *M. marginale* from thinleaf alder was included in this study. Preliminary reports have been published (Shamoun 1991, Shamoun *et al.* 1992).

## Materials and methods

### Isolates of *Melanconium* spp. and culture conditions

Twenty isolates of *M. apiocarpum* and *M. marginale* were studied. The origin, type (SE or DSA), and host of the isolates are given in Table 1. Following incubation at 20°C for 14 days on acidified potato dextrose agar, 1-$cm^2$ squares were cut from the periphery of fungal colonies and used to inoculate sterile V8 juice medium (Benhamou *et al.* 1984). Each isolate was grown in 100-ml aliquots of medium, in each of five 250-ml Erlenmeyer flasks at 25°C for 14 days. The mycelium from each

Table 1. Hosts and origins of *M. apiocarpum* and *M. marginale* isolates (SE = Symptomless Endophytes; DSA = Disease Syndrome Associated isolates).

| Isolate | Species/Type | Host | Origin |
|---|---|---|---|
| PFC 043 | *M. apiocarpum*/DSA | *Alnus rubra* | Victoria, B.C. |
| PFC 047 | *M.apiocarpum* /DSA | *A. rubra* | De Courcy Island, B.C. |
| PFC 050 | *M. apiocarpum*/DSA | *A. rubra* | N.W. Bay, B.C. |
| PFC 053 | *M. apiocarpum*/DSA | *A. rubra* | Sombrio Beach, B.C. |
| PFC 055 | *M. apiocarpum*/DSA | *A. rubra* | Jordan River, B.C. |
| PFC 067 | *M. apiocarpum*/SE | *A. rubra* | Jordan River, B.C. |
| PFC 068 | *M. apiocarpum*/SE | *A. rubra* | Cowichan Lake, B.C. |
| PFC 071 | *M. apiocarpum*/SE | *A. rubra* | Campbell River, B.C. |
| PFC 147 | *M. apiocarpum*/SE | *A. rubra* | Jordan River, B.C. |
| PFC 155 | *M. apiocarpum*/SE | *A. rubra* | Gold Stream, B.C. |
| PFC 022 | *M. marg.*/DSA | *A. rubra* | Metchosin, B.C. |
| PFC 025 | *M. marg.*/DSA | *A. rubra* | Kennedy Lake, B.C. |
| PFC 049 | *M. marg.*/DSA | *A. rubra* | Galiano Island, B.C. |
| PFC 051 | *M. marg.*/DSA | *A. rubra* | Mesachie Lake, B.C. |
| PFC 078 | *M. marg.*/DSA | *A. tenuifolia* | Northern Idaho, U.S.A. |
| PFC 013 | *M. marg.*/DSA | *A. viridis* | Kootenay, B.C. |
| PFC 083 | *M. marg.*/DSA | *A. viridis* | Nakusp Hot Springs, B.C. |
| PFC 084 | *M. marg.*/DSA | *A. viridis* | Prophet River, B.C. |
| PFC 091 | *M. marg.*/DSA | *A. viridis* | Northwest Territory, Canada |
| PFC 092 | *M. marg.*/DSA | *A. viridis* | Nakusp Hot Springs, B.C. |

isolate was harvested by suction filtration through Whatman no. 4 qualitative filter paper, removing any inoculum agar squares in the process. The remaining mycelium was rinsed with distilled water, weighed, and frozen at -20°C. The frozen samples were then freeze dried for 48 hours. The resulting mycelial cakes were homogenized using a cold mortar and pestle (previously stored at -20°C) to which 5 g of dry ice and 10 ml of cold acetone were added. The homogenate was subsequently suction filtered through Whatman no. 1 filter paper and the resulting "acetone powder" was scraped off with a razor blade, weighed and stored at -20°C.

### Protein extraction and determination

Proteins were extracted by placing 100 mg of the acetone powder and 1.0 ml of extraction solution (0.004 M $NaHCO_3$) into 1.8-ml microcentrifuge tubes. These were left overnight at 4°C and centrifuged in an Eppendorf microcentrifuge (model 5415) at 14 000 rpm (RCF = 16 000 x g) for 30 minutes. The resulting clear supernatant was collected and, by using Bradford's method (Bradford 1976), the protein content of each isolate sample was determined.

Protein supernatant solutions of *Melanconium* spp. were then diluted in 0.004 M $NaHCO_3$ to a protein content of 500 μg/sample. Each 400 ml volume of standardized supernatant was amended with 40 ml of 0.25% bromophenol blue and 60 ml of 20% glycerol. The resulting solutions were dispensed into 50 ml aliquots and frozen at -20°C in 1.8-ml microcentrifuge tubes until use. Samples were kept on ice when not frozen during the aforementioned procedures to minimize any possible protein degradation prior to electrophoresis.

### Polyacrylamide gel electrophoresis

Protein separation was performed using 7.5% acrylamide slab gels (0.75 mm x 12 cm x 17 cm) in a vertical gel electrophoresis system (Bethesda Research Laboratories model V16). A support backing (Gel Bond polyacrylamide gel support medium) was used to enable easy handling of the gels. Samples were thawed on ice, and 25 μl of each protein sample solution were applied per well. All 20 isolates were separated during a single electrophoretic run and each run was repeated twice. A constant current of 5 mA (using a Searle Buchler 3-1500 constant power supply) was applied while samples migrated through the stacking gel and subsequently increased to 15 mA as proteins moved through the separating gel. Electrophoresis was carried out at 1 C until the bromophenol blue solvent front was approximately 1.0 cm from the bottom of the gel. Gels were then stained for non-SDS total protein, acid phosphatase, alkaline phosphatase, alcohol dehydrogenase, aspartate aminotransferase, beta-esterase, beta-glucosidase, glutamate dehydrogenase, hexokinase, isocitrate dehydrogenase, malate dehydrogenase and phosphoglucomutase according to the methods described by Cheliak and Pitel (1984). Peroxidase and polyphenoloxidase were assayed by using L-DOPA as substrate (Kieliszewska-Rockicka, 1980). Following the staining procedure, gels were rinsed, fixed and preserved in a 30% ethanol - 10% acetic acid - 10% glycerol solution (V/V) for approximately half an hour. Gels were then covered with cellophane preserving sheets (Pharmacia LKB 1850-221), left overnight to dry to room temperature, and later photographed. Zymograms were constructed and relative migration (Rf) values were determined as the distance of the band migration from the origin divided by the distance travelled by the tracking dye front.

### Pathogenicity tests

Mature apple fruits (cultivar Golden Delicious) were surface-sterilized with 95% ethanol, then puncture-wounded (5 mm diameter, 5 mm deep) at a single location of apple tissue. Five apples were inoculated with each *Melanconium apiocarpum* (SE and DSA) isolate, and each *M. marginale* isolate. Controls consisted of apples inoculated with sterile disks of the acidified potato dextrose agar. Inoculated apples were placed in polyethylene bags and incubated at 25°C for 14 days. Lesion diameters were measured and recorded as radial measurements from the edge of the wound.

## Results

### Yield of mycelium, acetone powder and protein contents of of *Melanconium apiocarpum* (SE and DSA) and *M. marginale* isolates

There were no differences in the yield of acetone powder (mg/500 ml medium) between SE ($\overline{X} = 238$; s.d. = 33.10) and DSA ($\overline{X} = 252$; s.d. = 35.44) isolates of *M. apiocarpum,* but *M. marginale* isolates yielded more acetone powder (mg/500 ml medium) ($\overline{X} = 460$; s.d. = 48.99) than *M. apiocarpum* isolates. The protein contents (μg/mg acetone powder of mycelium) of the *M. marginale* isolates ($\overline{X} = 80.42$, s.d. = 10.87) were consistently higher than those of both SE ($\overline{X} = 30.88$, s.d. = 10.87) and DSA ($\overline{X} = 31.71$, s.d. = 10.01) of *M. apiocarpum* isolates (Fig. 1).

### Detection of protein and isozyme patterns on gels

The non-SDS electrophoretic protein patterns revealed no major qualitative differences between DSA and SE *M. apiocarpum* isolates. However, isolates of *M. marginale* can readily be distinguished from *M. apiocarpum* by three fast-moving protein bands at $R_f$ 0.82 in isolates PFC 051, PFC 078 and PFC 013, and slow-moving protein bands at $R_f$ 0.21 (Fig. 2).

Among the 13 enzyme systems tested, only 7 showed positive activity (Table 2). However, only β-esterase, peroxidase and polyphenoloxidase patterns allowed differentiation between *M. apiocarpum* and *M. marginale* isolates; moreover, there were no differences between DSA and SE of *M. apiocarpum* isolates.

### Esterase (β-EST; E.C.3.1.1.1)

#### a) *Melanconium apiocarpum*

Six bands of esterase were detected among DSA and SE isolates of *M. apiocarpum.* Bands of $R_f$ 0.65, 0.73 and 0.80 were present in all isolates. Bands at $R_f$ 0.64 were present in all isolates except PFC 043 and PFC 047. Bands at $R_f$ 0.52 were present only in isolates PFC 050, PFC 053 and PFC 068; while bands at $R_f$ 0.60 were

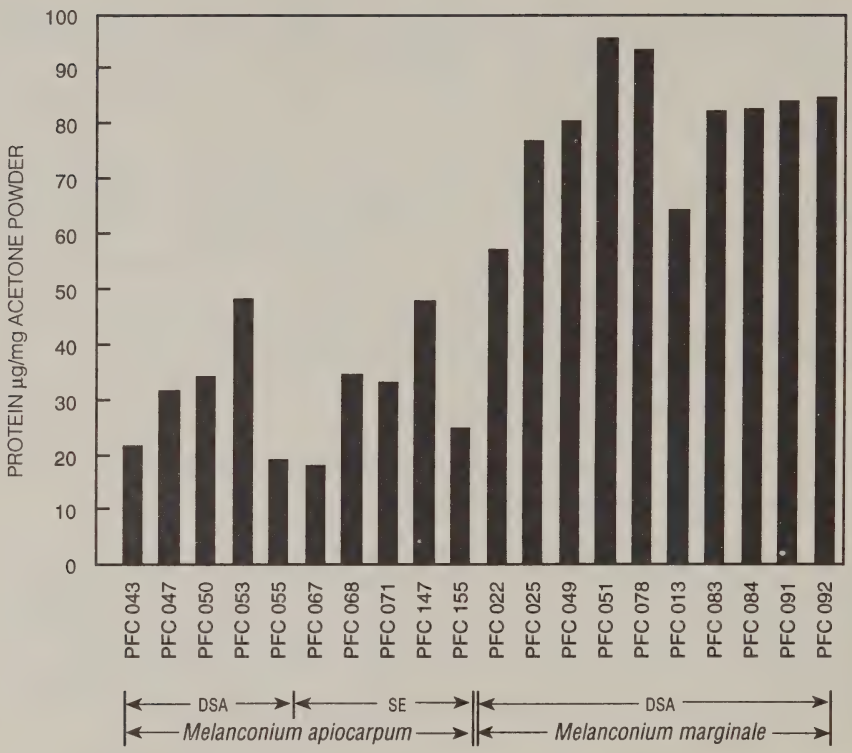

Fig. 1. Protein content of *Melanconium apiocarpum* and *Melanconium marginale* isolates (SE = Symptomless Endophytes; DSA = Disease Syndrome Associated isolates).

absent only in isolates PFC 050, PFC 053 and PFC 068 (Figures 3 and 4). Consistent differences between DSA and SE isolates could not be detected.

### b) *Melanconium marginale*

Banding pattern varied considerably among isolates (Figures 3 and 4). There were only three isolates with the same pattern: PFC 013, PFC 049 and PFC 051.

## Peroxidase (PER; E.C.1.11.1.7)

### a) *Melanconium apiocarpum*

Banding patterns were uniform. All isolates had bands at $R_f$ 0.26 and 0.29 (Figures 5 and 6).

Table 2. Summarized results of enzyme activities tested in *Melanconium apiocarpum* and *Melanconium marginale* isolates

| Enzyme | Reaction[a] |
|---|---|
| Acid phosphatase (ACP; E.C.3.1.3.2) | + |
| Alkaline phosphatase (ALP; E.C.3.1.3.1) | - |
| Alcohol dehydrogenase (ADH; E.C.1.1.1.1) | - |
| Aspartate aminotransferase (AAT; E.C.2.6.1.1) | - |
| Beta-esterase (β-EST; E.C.3.1.1.1) | + |
| Beta-glucosidase (β-GLUC; E.C.3.2.1.21) | + |
| Glutamate dehydrogenase (GDH; E.C.1.4.1.3) | - |
| Hexokinase (HK; E.C.2.7.1.1) | - |
| Isocitrate dehydrogenase (IDH; E.C.1.1.1.42) | - |
| Malate dehydrogenase (MDH; E.C.1.1.1.37) | + |
| Peroxidase (PER; E.C.1.11.1.7) | + |
| Phosphoglucomutase (PGM; E.C.2.7.5.1) | + |
| Polyphenoloxidase (PPO; E.C.1.14.18.1) | + |

[a] + = Positive reaction
- = Negative reaction

**b) *Melanconium marginale***

Isolates PFC 025, PFC 083, PFC 084, PFC 091 and PFC 092 showed the same banding pattern and had bands at $R_f$ 0.27 and 0.31. In addition to bands at $R_f$ 0.27 and 0.31, isolates PFC 049 and PFC 078 had an extra band at $R_f$ 0.42 and 0.37, respectively. Isolate PFC 022 had one band at $R_f$ 0.31 and isolate PFC 051 and PFC 013 had common band at $R_f$ 0.33 (Figures 5 and 6).

**Polyphenoloxidase (PPO; E.C.1.14.18.1)**

**a) *Melanconium apiocarpum***

Bands at $R_f$ 0.21 and 0.38 common to all SE and DSA isolates were detected (Figures 7 and 8).

**b) *Melanconium marginale***

Isolates PFC 022, PFC 0.25, PFC 049, PFC 083, PFC 084, PFC 091 and PFC 092 had one common band at $R_f$ 0.41. Isolate PFC 049 had an additional band at $R_f$ 0.36. Isolates PFC 051, PFC 078 and PFC 013 had one common band at $R_f$ 0.44 (Figures 7 and 8).

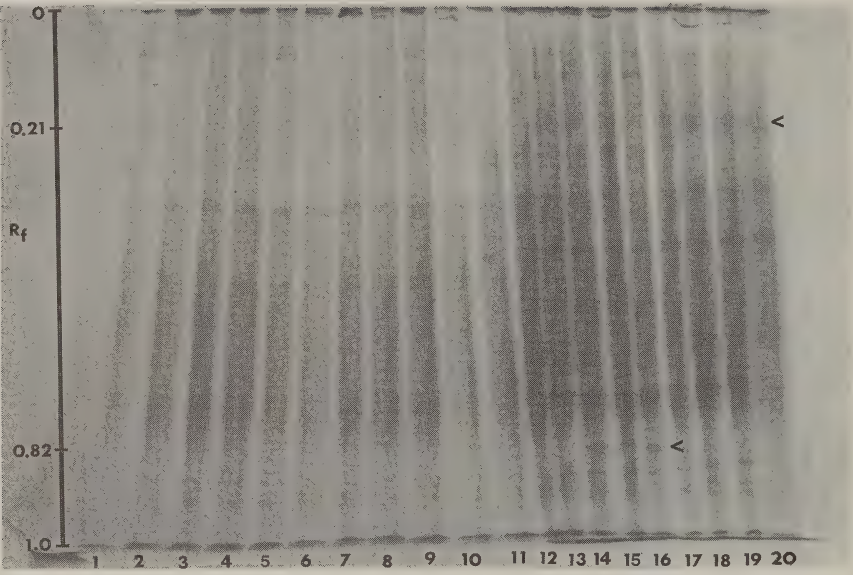

Fig. 2. Non-SDS general protein profiles of *Melanconium apiocarpum* and *Melanconium marginale* isolates: Lanes (1-5), *M. apiocarpum* (DSA); and Lanes (6-10) *M. apiocarpum* (SE); Lanes (11-20) *M. marginale* (DSA). <, protein bands that are different between *M. apiocarpum* and *M. marginale.* Note the presence of 3 fast moving protein bands at $R_f$ 0.82 (lanes 14, 15 and 16); and slow moving bands at $R_f$ 0.21.

## Pathogenicity of *M. apiocarpum* and *M. marginale* on apples

Isolates of *M. marginale* isolates showed more virulence than *M. apiocarpum* isolates. No obvious differences were noted among SE and DSA isolates of *M. apiocarpum* (Figures 9 and 10).

## Discussion

The results of this study demonstrate certain differences and similarities among isolates of *Melanconium* spp. with respect to their protein and isozyme patterns. Of 13 enzymes screened, seven showed positive activities (acid phosphatase, β-esterase, β-glucosidase, malate dehydrogenase, peroxidase, phosphoglucomutase and polyphenoloxidase). This relatively high proportion of positive enzyme activities corresponds well with that of the potential mycoherbicide *Chondrostereum purpureum* (Pers: Fr.) Pouz. isolates (Shamoun *et al.* 1991a, 1991b), which showed positive activities for 8 of 13 enzymes tested. Similar results were also obtained by Alfenas *et al.* (1984) in their studies on *Eucalyptus* canker caused by *Cryphonectria cubensis* (Bruner) Hodges. Isolates of this pathogen could be differentiated best on the basis of seven isozyme systems, namely aspartate aminotransferase, β-esterase, hexokinase, malate dehydrogenase, peroxidase, phosphoglucomutase, and polyphenoloxidase.

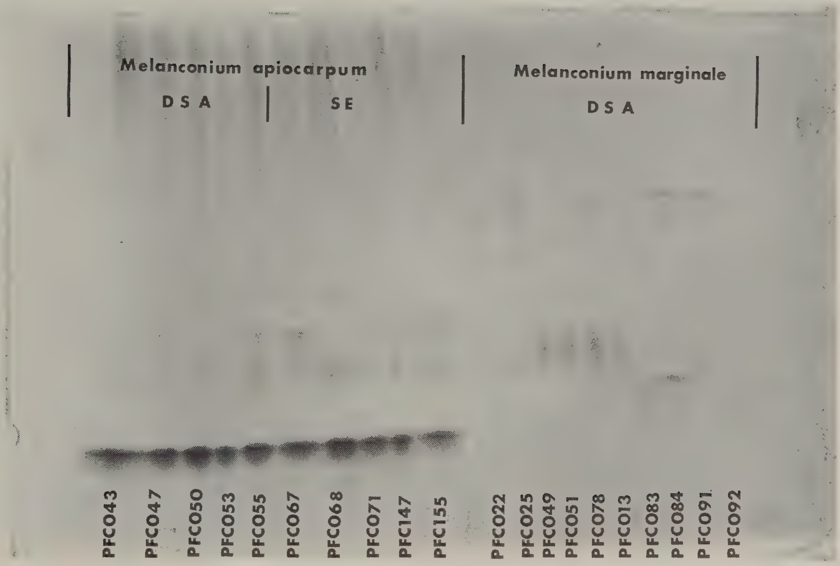
Melanconium apiocarpum
DSA
SE
Melanconium marginale
DSA
PFC043
PFC047
PFC050
PFC053
PFC055
PFC067
PFC068
PFC071
PFC147
PFC155
PFC022
PFC025
PFC049
PFC051
PFC078
PFC013
PFC083
PFC084
PFC091
PFC092

Fig. 3. Isozyme banding patterns of β-esterase of *Melanconium apiocarpum* and *M. marginale* isolates.

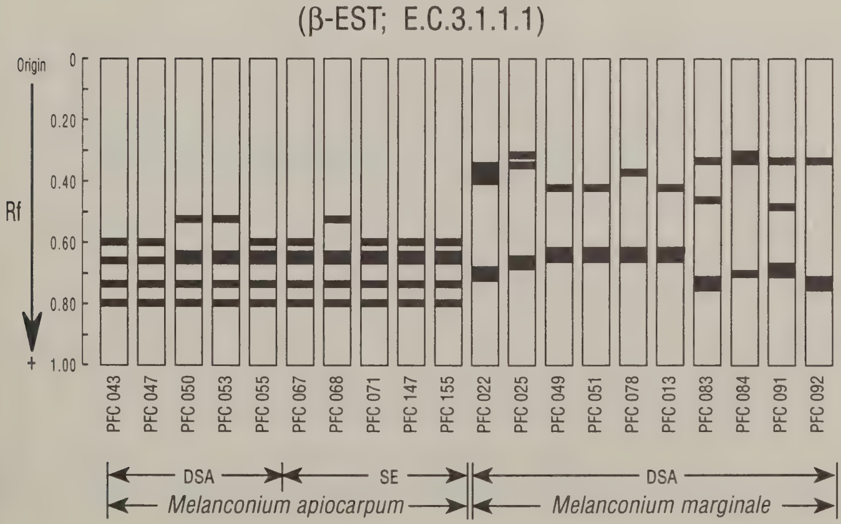
(β-EST; E.C.3.1.1.1)
Origin
0
0.20
0.40
0.60
0.80
1.00
Rf
+
PFC 043
PFC 047
PFC 050
PFC 053
PFC 055
PFC 067
PFC 068
PFC 071
PFC 147
PFC 155
PFC 022
PFC 025
PFC 049
PFC 051
PFC 078
PFC 013
PFC 083
PFC 084
PFC 091
PFC 092
DSA
SE
DSA
Melanconium apiocarpum
Melanconium marginale

Fig. 4. Zymogram and $R_f$ values of β-esterase patterns of *Melanconium apiocarpum* and *M. marginale* isolates.

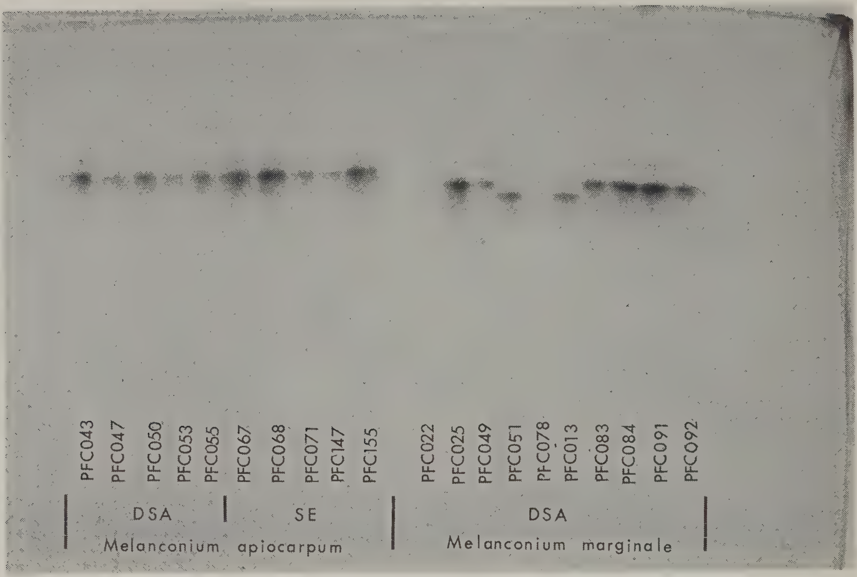
PFC043
PFC047
PFC050
PFC053
PFC055
PFC067
PFC068
PFC071
PFC147
PFC155
PFC022
PFC025
PFC049
PFC051
PFC078
PFC013
PFC083
PFC084
PFC091
PFC092
DSA
SE
Melanconium apiocarpum
DSA
Melanconium marginale

Fig. 5. Isozyme banding patterns of peroxidase of *Melanconium apiocarpum* and *M. marginale* isolates.

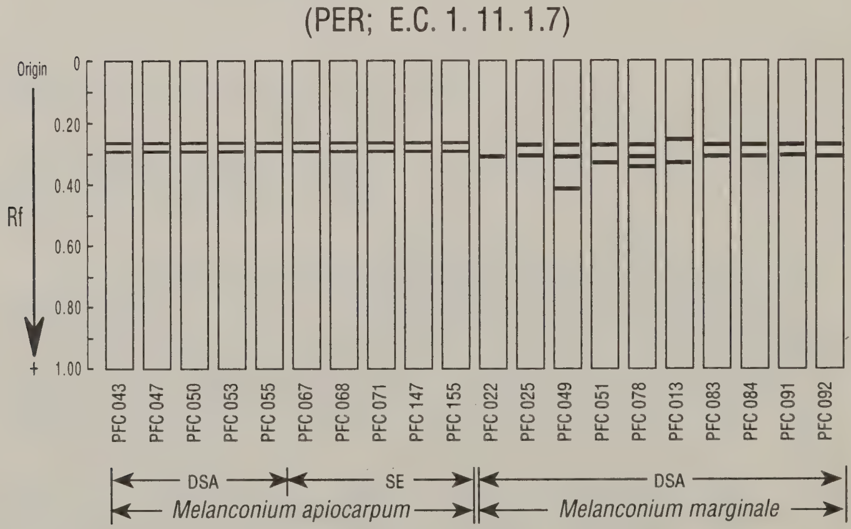
(PER; E.C. 1. 11. 1.7)
Origin
0
0.20
0.40
0.60
0.80
1.00
Rf
+
PFC 043
PFC 047
PFC 050
PFC 053
PFC 055
PFC 067
PFC 068
PFC 071
PFC 147
PFC 155
PFC 022
PFC 025
PFC 049
PFC 051
PFC 078
PFC 013
PFC 083
PFC 084
PFC 091
PFC 092
DSA
SE
DSA
Melanconium apiocarpum
Melanconium marginale

Fig. 6. Zymograms and $R_f$ values of the peroxidase patterns of *Melanconium apiocarpum* and *M. marginale* isolates.

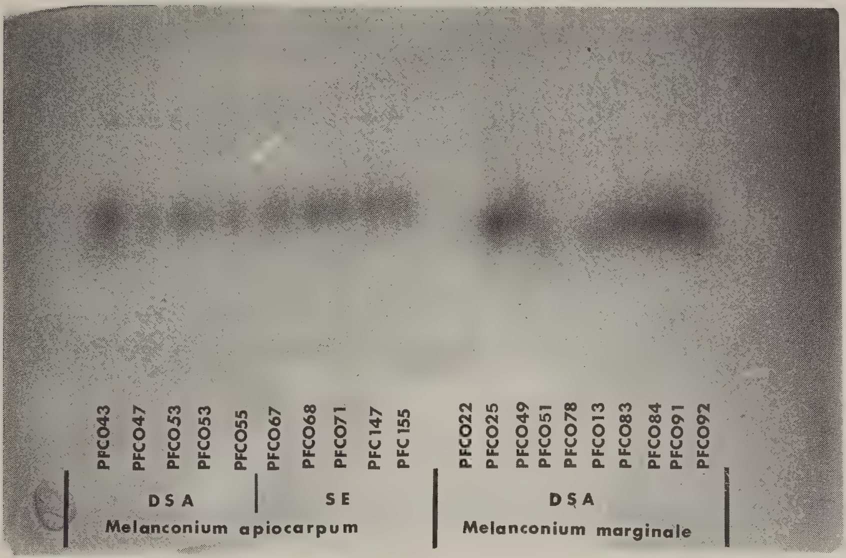
PFCO43
PFCO47
PFCO53
PFCO53
PFCO55
PFCO67
PFCO68
PFCO71
PFC147
PFC155
PFCO22
PFCO25
PFCO49
PFCO51
PFCO78
PFCO13
PFCO83
PFCO84
PFCO91
PFCO92
DSA
SE
DSA
Melanconium apiocarpum
Melanconium marginale

Fig. 7. Isozyme banding patterns of polyphenoloxidase of *Melanconium apiocarpum* and *M. marginale apiocarpum* and *M. marginale* isolates.

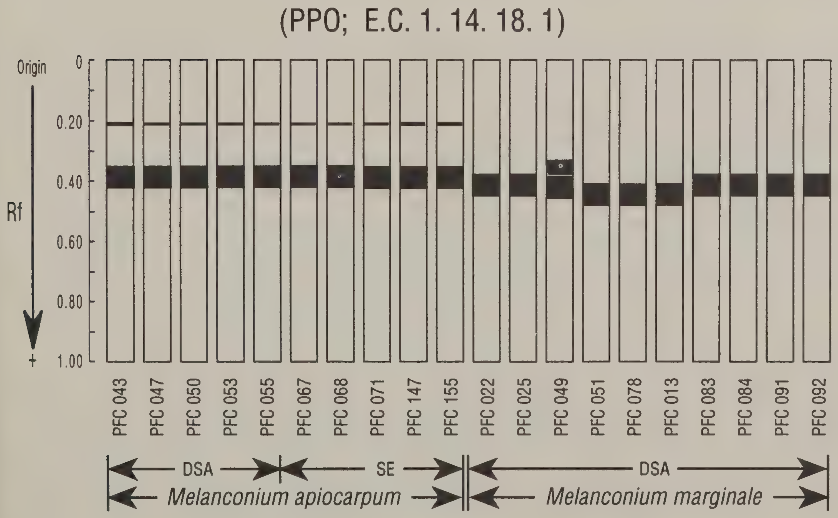

Fig. 8. Zymograms and $R_f$ values of the polyphenoloxidase of *Melanconium apiocarpum* and *M. marginale* isolates.

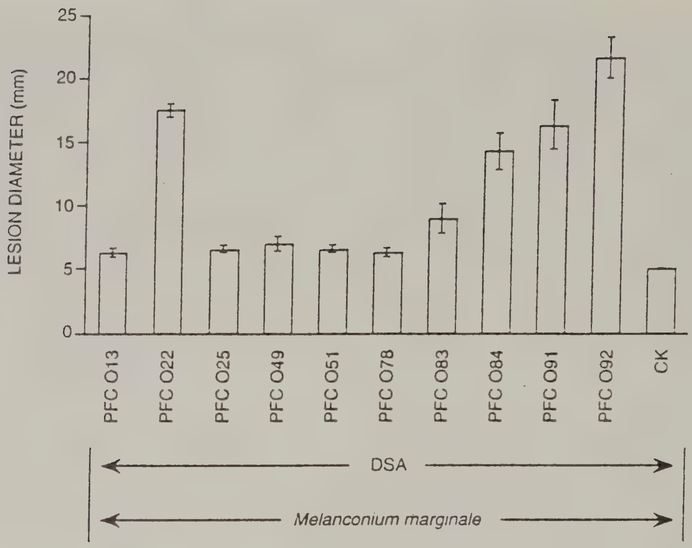

Fig. 9. Relative virulence of *Melanconium marginale* isolates on apple fruit. CK = Controls. There were five replicates per treatment and the vertical bars represent standard error of mean.

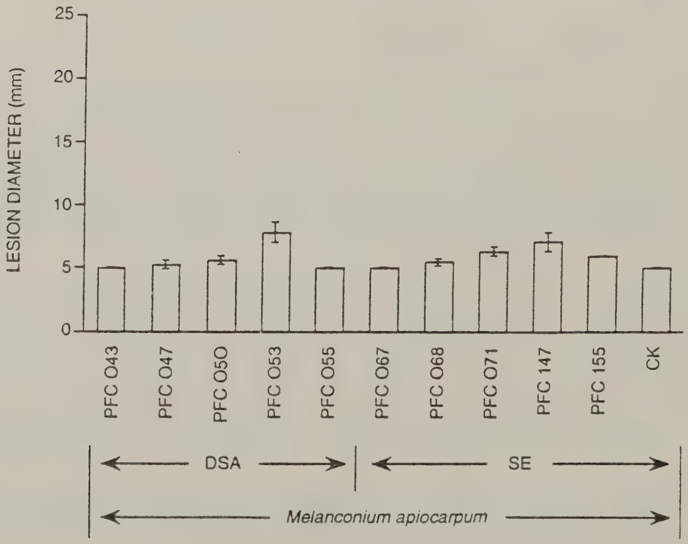

Fig. 10. Relative virulence of *Melanconium apiocarpum* on apple fruit. CK = controls. There were five replicates per treatment and the vertical bars represent standard error of mean.

Isozyme banding patterns produced by β-esterase, peroxidase and polyphenoloxidase varied much more among *M. marginale* isolates than among *M. apiocarpum* isolates. Whereas Sieber *et al.* (1991b) demonstrated that differences in both conidial morphology and protein profiles (SDS-polyacrylamide gel electrophoresis) of *M. marginale* isolates were (in part) due to the host from which they were isolated; differences in isozyme patterns could not be attributed to different hosts in this study.

By using SDS-polyacrylamide gel electrophoresis, Sieber *et al.* (1991b) showed no differences between SE and DSA isolates of *M. apiocarpum* from *A. rubra*, but they were able to differentiate between *M. apiocarpum* and *M. marginale* isolates. Although the treatment of proteins with negatively charged SDS is widely used in polyacrylamide gel electrophoresis for determining the molecular weights of proteins, the binding of SDS to the polypeptide chains of proteins also causes them to unfold and dissociate (Payne, 1976). Lin *et al.* (1989) suggested that by keeping the proteins in their natural forms, better differentiation between biological species of *Armillaria* was possible. Although an extensive quantitative analysis was not performed on the non-SDS total protein assay in the present study, no obvious qualitative differences were found between SE and DSA isolates of *M. apiocarpum.* On the other hand, isolates of *M. marginale* could be differentiated by non-SDS electrophoresis protein patterns from *M. apiocarpum* isolates based on protein bands at $R_f$ 0.21 and 0.82 (Fig. 2).

Our data, based on the analysis of three enzyme systems (β-esterase, peroxidase and polyphenoloxidase) demonstrated that isozymes can be used as biochemical markers to differentiate between *M. marginale* from *M. apiocarpum* isolates. Isozyme analysis proved to be a highly reliable method since these results were perfectly reproducible.

There were no differences in mycelial fresh weight, acetone powder weight and protein contents (Fig. 1) between SE and DSA isolates of *M. apiocarpum,* but acetone powder weight and protein contents of *M. marginale* were consistently greater than those of *M. apiocarpum.* The same trend was true with respect to relative virulence on apple fruits (Figures 9 and 10), where *M. marginale* isolates were more virulent than *M. apiocarpum* isolates. No obvious differences were noted among SE and DSA isolates of *M. apiocarpum.* Thus, measurements of acetone powder, protein contents, and relative virulence on apples could be used alone or in conjunction with three isozyme systems (β-esterase, peroxidase and polyphenoloxidase) analysis to differentiate between *M. marginale* and *M. apiocarpum* isolates.

This study confirms the findings of Jensen (1984) and Sieber *et al.* (1991b) that *M. apiocarpum* and *M. marginale* are distinct species. We could not detect differences between SE and DSA isolates of *M. apiocarpum* from *A. rubra.* Future research is directed toward stimulation of the endophytic fungi to promote them to the pathogenic phase, by using specific predisposing factors (chemical, mechanical or environmental), to permit effective utilization of the endophytes as biocontrol agents (mycoherbicides) for alder on reforestation sites.

## Acknowledgements

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# ICONES ASCOMYCETUM VENEZUELAE:

# MELANOSPORA ZAMIAE

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## ABSTRACT

A perithecial ascomycete growing in association with *Fusarium* sp. isolated from diseased safflower roots in Venezuela was identified as *Melanospora zamiae* Corda. This species forms ostiolate perithecia containing one-celled, brown, citriform ascospores with smooth walls and a depressed germ pore at each end of the spore. Since this is the first published report of a species of *Melanospora* from Venezuela, an illustrated description is provided as an aid to identification.

**Keywords:** Ascomycotina, *Carthamnus tinctorius*, Melanosporaceae, safflower, Sordariales.

## RESUMEN

Un ascomiceto peritecial creciendo en asociación con *Fusarium* sp. se aisló de raices enfermas de alazor en Venezuela y se identificó como *Melanospora zamiae* Corda. Dicha especie forma peritecios ostiolados que contienen ascosporas unicelulares, marrones, con forma de limón, paredes lisas y un poro germinativo deprimido a cada extremo de la espora. Desde que este es el primer reporte publicado de una especie de *Melanospora* en Venezuela, se provee una descripción ilustrada del hongo.

During an investigation of a root disease problem in a commercial planting of safflower (*Carthanus tinctorius* L.; alazor, saflor) near Quibor, in Lara State, Venezuela, several fungi were isolated, one of which was a perithecial ascomycete. The latter was identified as *Melanospora zamiae* Corda, a species that commonly occurs on plant materials. Since this appears to be the first report of a species of *Melanospora* from Venezuela (Dennis, 1970; Urtiaga, 1986), an illustrated description of the Venezuelan material is provided.

## MATERIALS AND METHODS

Pieces of diseased host tissue at the margin of lesions were cut into ca. 1 mm squares, immersed in 70% ethanol for 20 min., passed through three rinses of distilled water, and plated on petri dishes containing water agar. Mycelium which had appeared after 48 hr was transferred to potato dextrose agar acidified with lactic acid to obtain pure cultures. The fungus was subsequently grown on 18% V-8 vegetable juice (V8) and malt extract (MEA) agars (Ulloa and Hanlin, 1978) for identification and study. Since V8 gave superior production of ascomata, the fungus was grown on this medium for all descriptions and photography.

Material grown on V8 agar was examined by light and scanning electron microscopy (SEM) and these observations were supplemented by sections. Material to be sectioned was killed and fixed in formalin-propionic acid-alcohol (FPA) and embedded in paraffin, following procedures described previously (Hanlin and Tortolero, 1989). For SEM of ascospores, a cleaned cover glass was mounted on a SEM stub with silver paste and allowed to dry in a desiccator. A suspension of ascospores was prepared by transferring a cirrhus from a perithecium to a tube of sterile, distilled water and shaking it on a Vortex shaker. A drop of the spore suspension was placed on the cover glass and dried overnight in a desiccator. When dry, the cover glass was coated with gold in a sputter coater and examined with a Phillips 505 scanning electron microscope. Measurements were made of ascomata, asci and ascospores mounted in water. Photographs were taken on Kodak Technical Pan film with a Nikon HFX camera on a Nikon SMZ stereo microscope or an Optiphot equipped with Nomarski differential interference contrast (DIC). SEM micrographs were taken with Polaroid Type 55 positive/negative film.

## OBSERVATIONS

Isolations from diseased root tissues yielded a *Fusarium* sp. on which the *Melanospora* later appeared. The *Melanospora* (#923) was subsequently obtained in pure culture by transferring clumps of spores from cirrhi at the tips of the ostiolar necks to fresh media.

**Melanospora zamiae Corda**
= *Ampullaria aurea* A. L. Smith
= *A. succinea* Petch
= ?*Gibsonia phaeospora* Massee
= *Melanospora acremonioides* (Harz) Vuill.
= *M. aspergilliformis* Eidam
= *M. cirrhata* Berk.
= *M. globosa* Berl.
= *M. helvellae* (Cooke) Sacc.
  ≡ *Ceratostoma helvellae* Cooke
= *M. mattiroliana* Mirande
= *M. pampeana* Speg.
= *M. rhizophila* Peglion & Sacc.
= *M. rhizophila* var. *macrospora* G. Arnaud
= *M. rollandi* Constantin
= *M. townei* Griffiths
= *Sphaeronema zamiae* Cattaneo

Anamorph: A monophialidic state has been reported (Calviello, 1973, 1976; Cookson, 1928; Doguet, 1955; Mason, 1933).

Mycelium growing rapidly on V8 agar at room temperature, forming a flat white colony with a loose, fluffy aerial mycelium that reaches 9 cm diam in 8 days. Ascoma an ostiolate perithecium (Figs. 1-3), scattered, solitary to occasionally aggregated, formed on surface of mycelium. Perithecia (355)-625-(743) μm high X (150)-246-(300) μm wide, with globose to subglobose venter and long ostiolar neck, glabrous or with scattered hairs, yellow-brown, with translucent walls, appearing darker when filled with spores. Ostiolar neck cylindrical to subconical, (158)-374-(474) μm long X (43)-48-(55) μm wide at top and (55)-68-(79) wide at base, composed of elongate, parallel hyphae (Figs. 5, 6), usually with a ring of hyaline bristles [(158)-227-(284) μm long] around apex of ostiole (Figs. 1, 4). Perithecial wall composed of pseudoparenchyma cells (textura globulosa) [(12)-17-(30) X (8)-13-(22)](Figs. 7-9) with conspicuous pores (Fig. 8); outermost cells with somewhat thickened, lightly pigmented walls (Fig. 8), inner cells thin-walled and hyaline. Centrum of young ascomata filled with large, thin-walled pseudoparenchyma cells. Paraphyses lacking. Asci clavate, (50)-69-(90)(SD=9.6, n=17) μm long X (20)-23-(26)(SD=1.7) μm wide, tapering to 4-6 μm wide at base, 8-spored, with thin, evanescent walls (Fig. 10). Ascospores 1-celled, citriform (Fig. 11), (14)-15-(16)(SD=0.7, n=25) μm X (9)-11.3-(12)(SD=0.8) μm, with dark brown walls, smooth (Figs. 12-14), with a depressed germ pore at each end (Figs. 12, 14), extruded in a gelatinous matrix at mouth of ostiolar neck (Fig. 3).

Isolated from leaves, bracts, and roots of *Carthamnus tinctorius* L. cv. NDS-1, in association with a *Fusarium* sp., Quibor, Edo. Lara, Venezuela. A. Carrasco (#214), March, 1990.
Etymology: *zamiae* = Latin, on *Zamia*, for the original host genus.

On malt extract agar growth was sparse and few ascomata formed.

Additional illustrations have been published by Arx and Müller (1954), Calviello (1973), Cannon and Hawksworth (1982), Cookson, (1928) and Doguet (1955). The synonymy above is from Mason (1933), Doguet (1955), and Cannon and Hawksworth (1982).

## DISCUSSION

Early generic concepts of *Melanospora* Corda included species with several morphological types of ascospores (Doguet, 1955) that were produced in ostiolate perithecia. Species with similar spores produced in non-ostiolate perithecia were placed in *Microthecium* Corda (Hawksworth and Udagawa, 1977; Udagawa and Cain, 1969). In a re-evaluation of *Melanospora*, Cannon and Hawksworth (1982) restricted the genus to species with smooth, citriform ascospores with a depressed germ pore at each end of the ascospore. Since the mere presence or absence of an ostiole is not considered to be a sufficiently important character on which to separate genera (Arx, 1973), *Microthecium* was reduced to synonymy with *Melanospora*, because the ascospores in the type species are smooth-walled and have depressed germ pores. Species with other types of ascospores were transferred to other genera. The Venezuelan material conforms to the restricted circumscription of *Melanospora*.

As reported by earlier workers (Calviello, 1973, 1976; Cookson, 1928; Doguet, 1955; Mason, 1933), a monophialidic state also was present in our cultures. Given the difficulty of separating the *Melanospora* from the microconidial state of the

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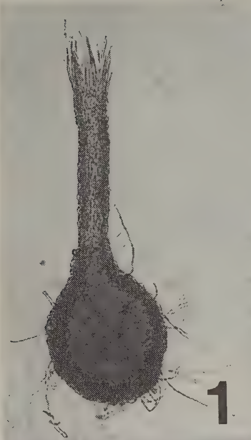
Figs. 1-10. *Melanospora zamiae*. Light and scanning electron (Figs. 4, 9) micrographs. Fig. 1. Mature perithecium with corona of setae on apex of ostiolar neck. X102. Fig. 2. Perithecium lacking ostiolar setae. Note hairs on venter of perithecium. X107. Fig. 3. Optical section through perithecium containing ascospores. X128. Fig. 4. Close-up of ostiolar setae. X170. Fig. 5. Portion of ostiolar neck composed of elongate hyphae. X1,000. Fig. 6. Oblique section through ostiolar neck and ostiole. X595. Fig. 7. Section through cells of perithecial wall. X550. Fig. 8. Close-up of perithecial wall cells in face view. Note pores in wall. X750. Fig. 9. Close-up of perithecial wall cells in section. Arrowhead indicates pore in wall. X840.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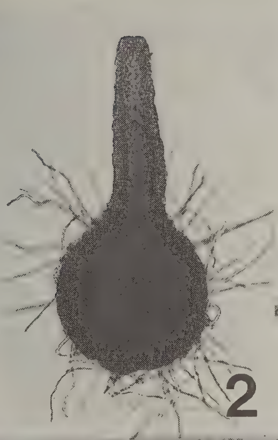
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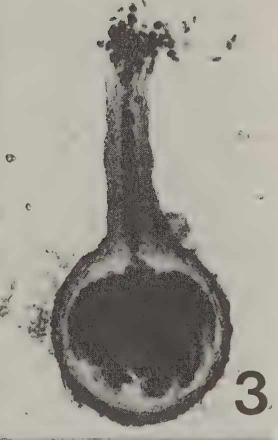
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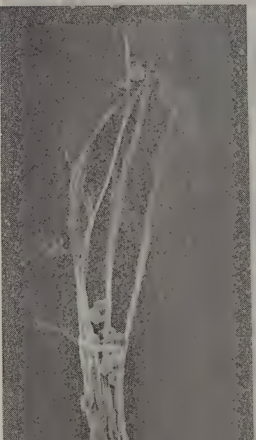
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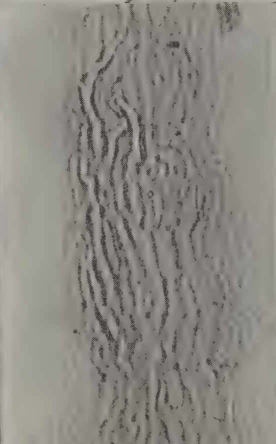
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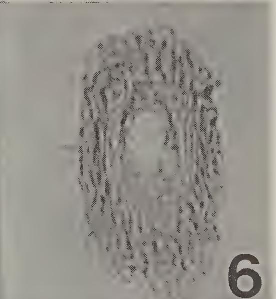
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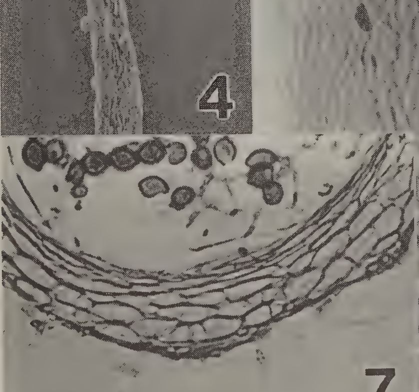
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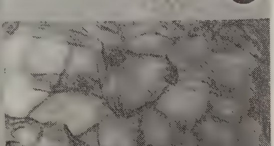
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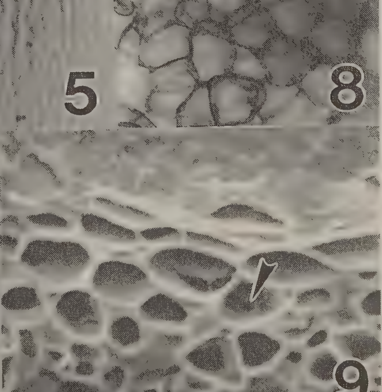
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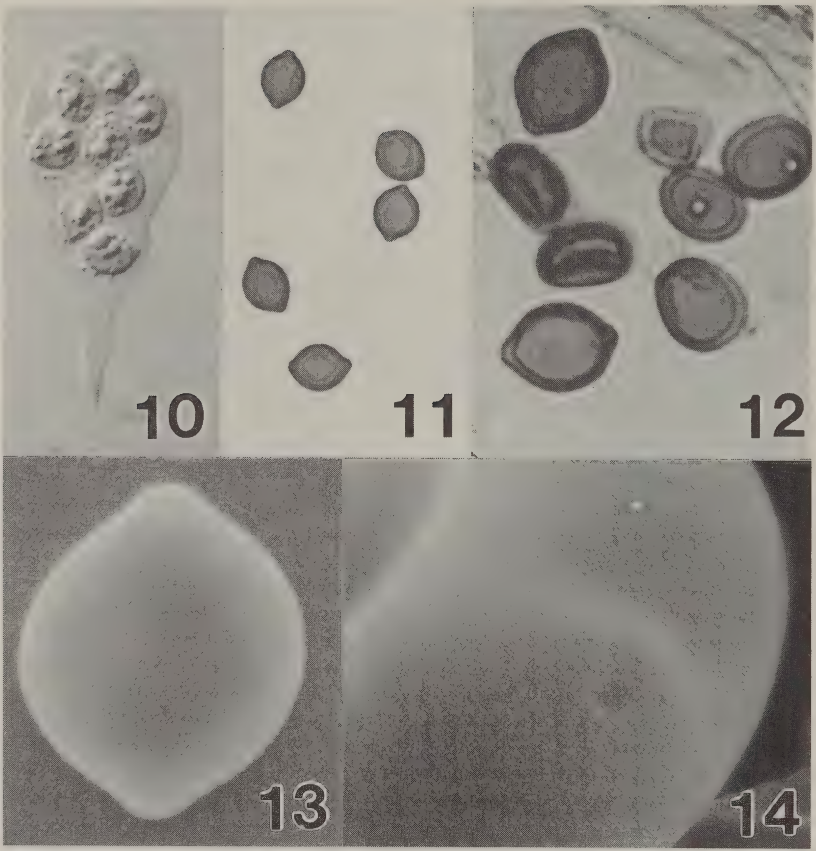

Figs. 10-14. *Melanospora zamiae*. Light and scanning electron (Figs. 13-14) micrographs. Fig. 10. Ascus with immature ascospores (Nomarski DIC). X923. Fig. 11. Mature citriform ascospores. X950. Fig. 12. Pores in ends of ascospores. X1,900. Fig. 13. Mature ascospore with smooth wall. X3,100. Fig. 14. Close-up of depressed, terminal germ pore. X11,725.

associated *Fusarium*, however, it is not described until it can be confirmed as the anamorph of *Melanospora* by single ascospore isolations.

The conspicuous pores in the perithecial wall cells observed here in *M. zamiae* were also reported in *M. sphaerodermoides* (Shoemaker and Smith, 1970).

Although *Melanospora zamiae* is a common soil-inhabiting fungus, it is also found in seeds (Malone and Muskett, 1964; Shoemaker and Smith, 1970), and other plant tissues, particularly in warm areas. It is frequently isolated in association with other fungi, especially *Fusarium* spp. When this isolate was given to the senior author it was thought to be a pathogen. No pathogenicity studies were conducted, but since *M. zamiae* is not considered to be phytopathogenic, it is more likely that the *Fusarium* was the cause of the disease on safflower. *Melanospora zamiae* has, however, been shown to be mycoparasitic on a variety of fungi (Jordan and Barnett, 1978). So far as can be determined, this is the first published report of a *Melanospora* from Venezuela, but records show that a melanosporaceous fungus was isolated earlier from garlic roots from the same region. Photographs taken of the garlic isolate do not show sufficient detail to identify it and unfortunately no material remains that can be checked. Besides Venezuela, *M. zamiae* also has been reported from Argentina (Calviello, 1973, 1976).

## ACKNOWLEDGMENTS

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# PHYLLACHORA TORRENDIELLA (Batista) comb. nov. RESPONSABLE DE LA MALADIE VERRUQUEUSE DU COCOTIER

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## Résumé:

La diagnose du *Catacauma torrendiella* Batista, agent de la maladie verruqueuse du cocotier ou "Lixa pequena", au Brésil est complétée ici par la description de structures stromatiques nouvelles correspondant à des spermogonies. L'ensemble des caractères morphologiques de ce champignon ainsi que les considérations de Petrak vis à vis de ce genre, nous ont conduits à renommer cette espèce sous *Phyllachora torrendiella* (Batista) comb. nov.

L'échantillon 4068 récolté par Balansa correspond à cette nouvelle combinaison *Phyllachora torrendiella.* Cet échantillon 4068 était associé jusqu'à présent, en raison d'une mauvaise détermination, avec le 3965 dans le protologue de l'*Auerswaldia rimosa* Speg.. Le spécimen 3965 devient donc le lectotype de l'*Auerswaldia rimosa* Speg. devenu *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller, agent de la "Lixa grande" sur cocotier.

## Summary:

The diagnosis of *Catacauma torrendiella* Batista, agent of the tar spot ("Lixa pequena"), foliar disease of the coconut palms in Brazil, is supplemented with the new description of stromata which correspond to spermogonia. The morphological characters of this fungus and Petrak's consideration of the genus *Catacauma*, lead us to give it the name *Phyllachora torrendiella* (Batista) comb. nov..

Specimen 4068, collected by Balansa agrees with the new combination *Phyllachora torrendiella*. Because of an incorrect determination, specimen 4068 was cited along with specimen 3965 in the protologue of *Auerswaldia rimosa* Speg. Specimen 3965 is selected as lectotype of *Auerswaldia rimosa* Speg., which is synonymous with *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller, agent of the "Lixa grande" on coconut palms.

## Resumo:

O diagnostico do *Catacauma torrendiella* Batista, agente da verrugose do coqueiro o Lixa pequena, no Brasil é completada aqui pela descripçao de estructuras estromaticas novas correspondente ao spermogonia. Todas as caracteristicas morfologicas deste fungo e as consideraçoes de Petrak sobre este gênero nos levara a dar um novo nome a esta espécie: *Phyllachora torrendiella* (Batista) comb. nov..

O material tipo 4068 coletado pelo Balansa corresponde a esta nova combinaçao *Phyllachora torrendiella*. Este material 4068 estava associado com erro junto ao 3965 no protologo de *Auerswaldia rimosa* Speg.. O material 3965 vai ser o lectotipo de *Auerswaldia rimosa* Speg. que agora é *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller, agente da Lixa grande em coqueiro.

Au Brésil, les plantations de cocotiers présentent une maladie foliaire dénommée "Lixa pequena", expression brésilienne signifiant "petite râpe". Cette maladie a été décrite sous le nom de maladie verruqueuse (Batista 1948, Roger 1953). En effet, celle-ci se manifeste par la présence de structures stromatiques noires saillantes sur les folioles entraînant le dessèchement prématuré des feuilles de l'arbre. Cette maladie cryptogamique est provoquée par un Ascomycète dont la position taxonomique est très controversée. En 1948, Batista le décrit sous le nom de *Catacauma torrendiella* ; mais récemment Bezerra (1991) propose de le rapprocher du genre *Sphaerodothis*.

Nous avons entrepris l'étude de cette espèce responsable de la "Lixa pequena" à partir de recherches bibliographiques et sur des observations d'échantillons frais ou provenant de l'herbier du Laboratoire de Cryptogamie du Muséum National d'Histoire Naturelle de Paris (PC).

## Description du pathogène, agent de la "Lixa pequena"

Seule la description morphologique peut à l'heure actuelle donner des renseignements sur la position systématique de cet Ascomycète. En effet, la culture axénique de ce champignon n'a pû, à ce jour être obtenue, malgré de nombreuses tentatives.

Sur les feuilles, l'Ascomycète apparaît sous forme de verrues noires, plus ou moins proéminentes, situées uniquement à la face supérieure des folioles, sur le rachis et parfois sur les noix. Elles sont rarement isolées, mais groupées le plus souvent en alignement simple dans le sens des nervures (fig. 1) ou en association plus complexe en forme de losange (fig. 2).

Microscopiquement, deux types de structures reproductrices sont présents sur les folioles.

Le premier type (fig. 3) correspond à des formes lenticulaires noires, brillantes, sous cuticulaires dans les stades les plus jeunes, formant à maturité des stromas ovoïdes qui présentent une fente longitudinale résultant de l'éclatement de la cuticule (fig. 8). Ces structures, apparues les premières dans les premiers stades de la maladie, contiennent des spores unicellulaires, hyalines, filiformes de 20 à 30 um de long et 1 µm de large, de type scolécospore (fig. 4). De nombreux auteurs (Orton 1944, Parbery et al. 1963, Hanlin 1990) les ont décrites chez les *Phyllachora* et considèrent qu'elles jouent le rôle de spermaties. Ces spores ne germent pas et leur inoculation sur feuille de cocotier n'a pas permis de reproduire les symptômes. Les stromas observés correspondent donc à des *spermogonies*.

Le deuxième type (fig. 3) correspond à d'autres structures stromatiques sphériques à subsphériques présentant un "dôme" au sommet, plus saillantes que les précédentes et qui renferment un *périthèce* (fig. 9). Leur taille est variable de 500 à 2000 µm de diamètre sur 100 à 800 µm de hauteur. La partie supérieure de ce stroma est perçée d'une ostiole autour de laquelle on observe une ornementation radiale (fig. 1). Le stroma contient un périthèce unique. Celui-ci est généralement garni d'asques simultanément matures (fig. 5) et immatures (fig. 6). Des paraphyses filiformes, septées et ramifiées s'insèrent entre les asques.

Les asques (fig. 5) sont nombreux, de forme cylindrique, légèrement claviforme. Nés sur des dangeardies ascogènes, ils conservent jusqu'à l'âge adulte une forme bifide à la base du pied de l'asque. Leur taille varie de 80 à 170 µm de long sur 18 à 25 µm de large. Les asques ne possèdent qu'une paroi hyaline et mince de type unituniqué. Le pied de l'asque est relativement court. Le système apical est inexistant.

Les ascospores (fig. 7) sont au nombre de huit au sein de l'asque. Les quatre premières ascospores situées au sommet de l'asque sont généralement disposées sur deux rangs et les quatre suivantes sur un rang. Elles sont fusoïdes et hyalines. Le contenu cytoplasmique est granuleux et contient le plus souvent des globules lipidiques. Ces ascospores sont symétriques, de 19 à 25 µm de long sur 7,5 à 10 µm de large et entourées d'une fine gaine de mucilage.

## Position systématique

L'agent pathogène de la "Lixa pequena" que nous venons de décrire, confronté aux échantillons d'herbier du M.N.H.N., correspond au spécimen n. 4068 récolté par Balansa en 1883 (PC) (F. Guar. 2:41, n.115), cité dans le protologue de l'*Auerswaldia rimosa* Speg.. Or, ce protologue fait référence à deux spécimens : le n. 3965 sur foliole d'*Acrocomia* ("Guarapi Brésil, Août 1883") et le n. 4068 sur foliole de *Butia yatai* (ex *Cocos yatai* ) ("Peribebuy, Paraguay, Novembre 1883"). Les observations macro- et microscopiques de ces deux spécimens permettent d'établir qu'ils sont très différents. Le spécimen n. 3965 présente des ascospores brunes, critère typique des *Sphaerodothis* (Shear 1909; Joly 1961; Verona et al. 1980) tandis que le n. 4068 est doté de spores hyalines quelle que soit la maturité des périthèces. La diagnose latine de l'*Auerswaldia rimosa* Speg. (F. Guar. 2:41, n.115) énonce des spores hyalines à l'état jeune devenant bien noires. Seul le spécimen n. 3965 présente cette coloration des spores. De ce fait, le spécimen n. 3965 de Balansa trouvé sur *Acrocomia* constitue le lectotype d'*Auerswaldia rimosa* Speg.. Depuis sa description en 1888 par Spegazzini, ce champignon a subi des remaniements taxonomiques. Il est devenu le *Sphaerodothis rimosa* (Speg.) Shear lors de la création du genre *Sphaerodothis* par Shear (1909) puis a été placé en synonymie avec le *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller sur la base de sa similitude morphologique et de la règle d'antériorité.

Le spécimen de Balansa n. 3965 est donc un *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller (anciennement nommé: *Coccostroma palmicola*), ascomycète que tous les mycologues s'accordent pour dire qu'il est sur *Cocos nucifera* L., l'agent de la "Lixa grande" .

L'agent de la "Lixa pequena", à ascospores hyalines correspond au spécimen n. 4068 de Balansa désigné également dans le protologue d'*Auerswaldia rimosa* par Spegazzini et ne présente jamais de spores brunes quel que soit le degré de maturité des périthèces observés. Ce champignon est très différent de celui du n. 3965 (que nous venons de considérer comme lectotype). Outre les critères précédemment énoncés sur la couleur des ascospores, on peut ajouter les caractères suivants. Le champignon de la "Lixa pequena" et le spécimen n. 4068 ont leurs stromas ascogènes surtout situés sur la face supérieure des folioles et sont ornementés radialement autour de l'ostiole. Les asques sont de forme cylindrique contenant des ascospores hyalines plutôt fusoïdes. Ces caractères s'opposent aux descriptions des *Sphaerodothis* (*Sphaerodothis acrocomiae* inclus). En effet, chez ces *Sphaerodothis,* les stromas ascogènes sont toujours de plus grande taille et situés de manière indifférente sur les deux faces des folioles. Aucune ornementation n'est visible sur ces stromas qui ont plutôt un aspect crevassé. Les asques sont clavés et très vite déliquescents libérant des ascospores brunes, ellipsoïdes à épispore noirâtre.

L'agent de la "Lixa pequena", au même titre que le spécimen n. 4068 de Balansa, n'est donc pas caractéristique des *Auerswaldia* et *Sphaerodothis*, contrairement à la proposition de Bezerra (1991) et ne peut donc pas correspondre au *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller.

Son étude systématique nous a conduit à le considérer comme un *Phyllachora*. L'agent de la "Lixa pequena" est décrit comme *Catacauma torrendiella* Batista sur cocotier en 1948, bien que le protologue ne mentionne pas les spermogonies. Le genre *Catacauma* a été créé par Theissen et Sydow (1915) à partir des *Phyllachora* (Nits. apud Fuck.) sur la base de la position sub-épidermique du stroma. Mais, ce genre *Catacauma* a été déclaré obsolète par Petrak (1927) considérant ce critère de positionnement dans les tissus de l'hôte difficilement utilisable, variable au cours du développement du champignon et pouvant prêter à confusion avec d'autres genres. Ce point de vue a été confirmé par de nombreux taxonomistes. Seuls quelques descripteurs d'espèces tropicales continuent encore d'utiliser le genre *Catacauma* (Jimenez et al., 1992)

En conséquence, il nous semble plus correct de considérer le *Catacauma torrendiella* comme un *Phyllachora* et nous proposons de le dénommer *Phyllachora torrendiella* (Batista) comb. nov. (Art. 55 - International Code of Botanical Nomenclature) en attendant une révision du genre *Phyllachora*. Le spécimen n. 4068 de Balansa, mal déterminé comme *Sphaerodothis rimosa*, est par voie de conséquence un *Phyllachora torrendiella*. Il s'avère donc que chez le *Butia yatai,* comme sur le *Cocos nucifera* L., il y a développement de deux champignons pathogènes: l'un à stromas très saillants et ascospores brunes: le *Sphaerodothis acrocomiae* (Montagne) v. Arx et Müller provoquant la "Lixa grande", et l'autre à stromas plus petits et ascospores hyalines: le *Phyllachora torrendiella* (Batista) comb. nov. responsable de la "Lixa pequena".

## Remerciements

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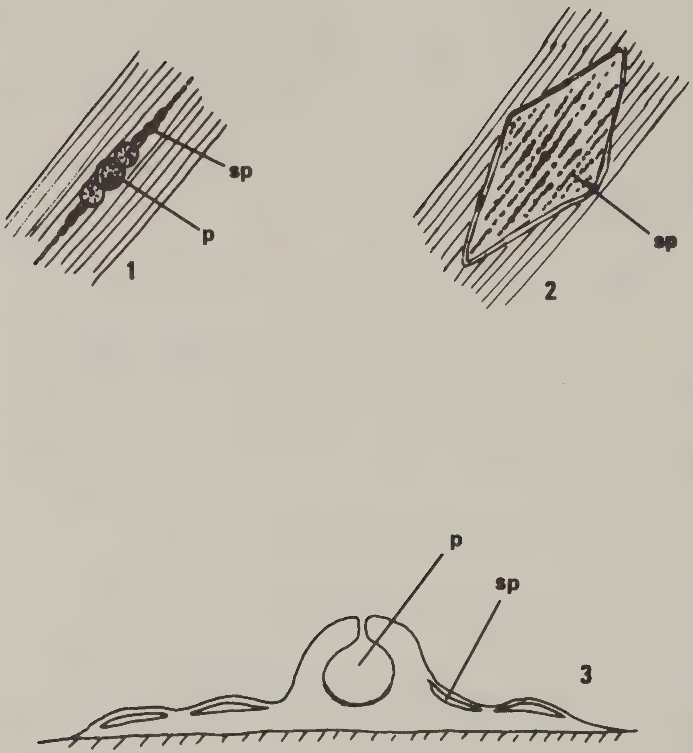
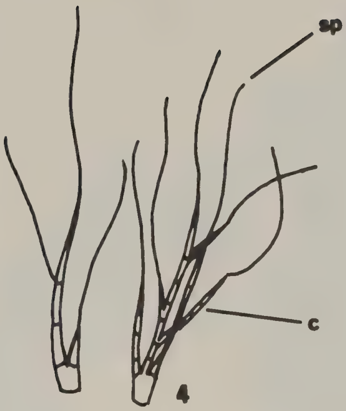


figures: 1. Symptôme de "Lixa pequena" en alignement simple
2. Symptôme de "Lixa pequena" en forme de losange
3. Schéma d'un symptôme de "Lixa pequena"
(p: périthèce; sp: spermogonie)



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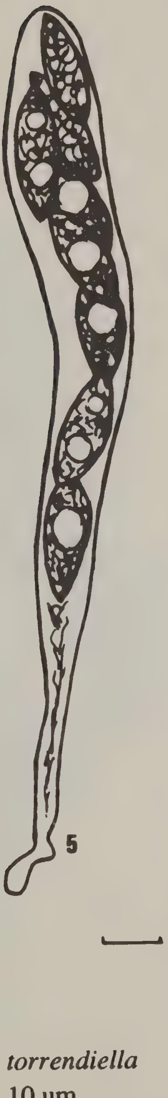

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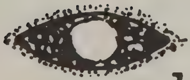

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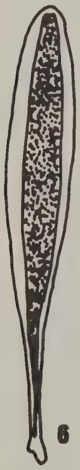

6

figures: 4: Contenu d'une spermogonie de *Phyllachora torrendiella* (sp: spermatie; c: conidiophore) - échelle: 10 µm

5: Asque mature de *Phyllachora torrendiella* - échelle: 10 µm

6: Asque immature de *Phyllachora torrendiella* - échelle: 6 µm

7: Ascospore de *Phyllachora torrendiella* - échelle: 8 µm

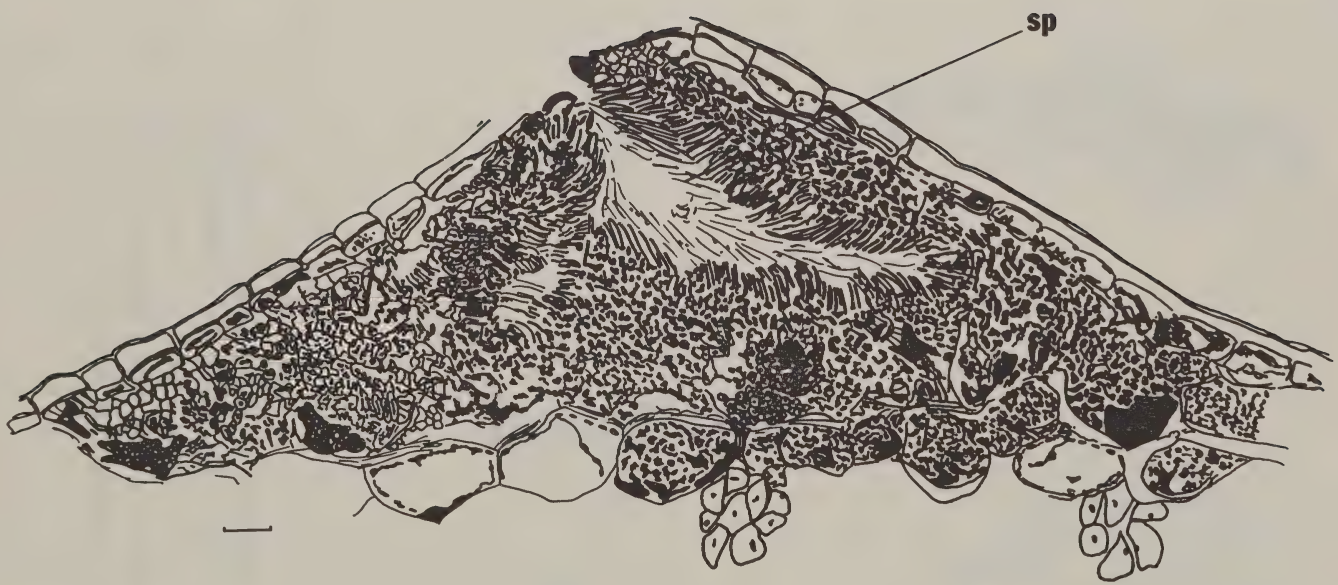

fig. 8: Spermogonie de *Phyllachora torrendiella* contenant des spermaties (sp) - échelle: 40 µm

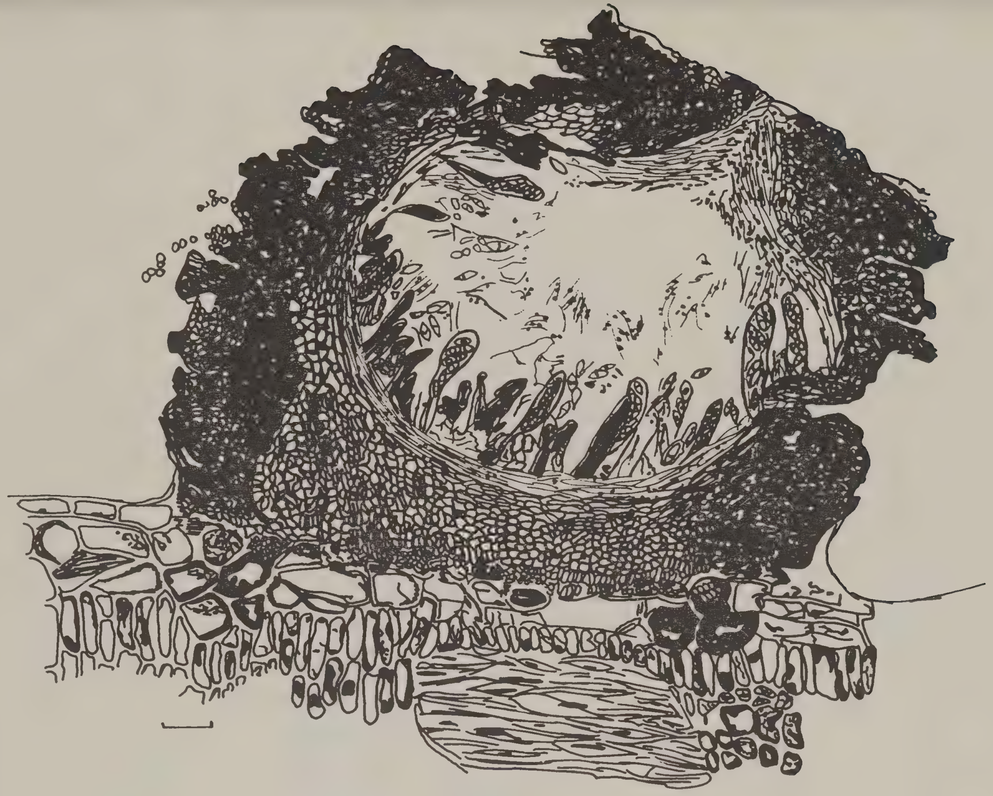

fig. 9: Périthèce de *Phyllachora torrendiella* contenant des asques à tous les stades de développement - échelle: 70 µm

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# TAXONOMIC RELEVANCE OF FATTY ACIDS OF ARBUSCULAR MYCORRHIZAL FUNGI AND RELATED SPECIES

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Fatty acid analyses were conducted on the spores of ten Zygomycetes species including seven arbuscular mycorrhizal fungi (AMF) of the genus Glomus, a saprobic zygosporic species, Endogone pisiformis, and species of the genera Acaulospora and Scutellospora. Eighty percent of the total fatty acids of these fungi consisted of C16:0, C18:0, C:18:1 and C:18:2. Alpha and gamma isomers of linolenic acid were only present in E. pisiformis spores. The trans configuration of the monounsaturated fatty acids (C16:1 and C:18:1) is, for the first time, reported for AMF. Taxonomic aspects of the fatty acid distribution in AMF spores and related species are discussed.

Des analyses d'acides gras ont été effectuées sur les spores de dix espèces de Zygomycetes dont sept endomycorhiziennes à arbuscules (MA) du genre Glomus, une espèce zygosporique saprophyte Endogone pisiformis, et deux espèces des genres *Acaulospora* et *Scutellospora*. Les acides gras en C16:0, C18:0, C:18:1 et C:18:2 constituent 80% des acides gras totaux. Les isomères *alpha* et *gamma* de l'acide linolénique n'ont été détectés que chez *E. pisiformis*. On rapporte pour la première fois chez les MA la présence d'acides gras monoinsaturés (C:16:1 et C:18:1) de configuration *trans*. Quelques aspects taxonomique de la distribution des acides gras chez les MA sont discutés.

## INTRODUCTION

It is generally accepted that arbuscular mycorrhizal fungi (AMF) evolved early in the history of vascular plants (Trappe, 1987). In spite of their geological age (Pirozynski & Dalpé, 1989) and their crucial role in plant development through time, little is actually known about their phylogenetic origins. In fact, their biochemical and physiological relationships with other Zygomycetes remain obscure; basic analyses are required for a more comprehensive understanding of phylogenetic and taxonomic relationships of these fungi.

The AMF species classification, based on spore morphology, comprises six genera grouped in three families: the Glomaceae with the genera *Glomus* and *Sclerocystis* (Pirozynski & Dalpé, 1989), the Acaulosporaceae with *Acaulospora* and *Entrophospora*, and the Gigasporaceae with *Gigaspora* and *Scutellospora* (Morton & Benny, 1990). the zygosporic species represented by the genus *Endogone* have never been found to be endomycorrhizal and are grouped in the family Endogonaceae.

Notwithstanding the functions differing and morphologies among the zygosporic and AMF spores, their predominant cytoplasmic constituent is lipid. This fact is clearly illustrated in some ultrastructural studies on *E. flammicorona* Trappe & Gerdemann (Bonfante-Fasolo & Scannerini, 1977), *E. pisiformis* Link: Fries (Gibson *et al.*, 1986) and *Gigaspora margarita* Becker & Hall (Sward, 1981). Lipid analyses performed on spores identified as *Acaulospora laevis* Gerdemann & Trappe (Beilby, 1980), *Glomus caledonium* Nicolson & Gerdemann) Trappe & Gerdemann (Beilby & Kidby, 1980), *Gi. margarita* and *G. intraradices* Schenck & Smith (Jabaji-Hare, 1988) confirmed these observations in estimating their total lipid content from 45 to 58% of the spore dry weight.

Comparative analysis of the spore lipid contents of various species from different genera is a logical biochemical investigation that may clarify the systematic position of these organisms. This report presents the results of a comparative study of the spore fatty acid composition of seven representatives of AMF and of three supposedly taxonomically related species.

## MATERIALS AND METHODS

The spores of ten fungal species representing the families Glomaceae, Acaulosporaceae, Gigasporaceae and Endogonaceae were analyzed for their fatty acid content. Voucher specimens for each of the studied fungi were deposited at the National Mycological Herbarium (DAOM), Agriculture Canada, Ottawa, Ont., Canada. The species studied were in alphabetical order: *Acaulospora nicolsonii* Walker, Reed & Sanders (DAOM 198323), *Endogone pisiformis* (DAOM 198008), *Glomus caledonium* (DAOM 194692), *G. intraradices* (DAOM 184739), *G. macrocarpum* Tulasne & Tulasne (DAOM 198467), *G. mosseae* (DAOM 198394), *Glomus rubiforme* Gerdemann & Trappe (DAOM 194703), *G. versiforme* (Karsten) Berch (DAOM 184103), *Glomus* sp. (DAOM 198468), and *Scutellospora fulgida* Koske & Walker (DAOM 198340). *Glomus rubiforme* and *E. pisiformis* were collected in the form of sporocarps, directly from their native substrates, respectively from the mycorhizosphere of *Fragaria virginiana* Duchesne and from the apex of *Sphagnum* sp. sporophytes. For all the other species, spores were extracted from the rhizosphere with *Allium porrum* L. as the host plant cultivated in pots of vermiculite. All species sporulated under growth chamber conditions of 22°C, 12/12 h day/night illumination of 2000 ft-candles, watered twice a week and fertilized bi-weekly with Hoagland nutrient solution, even though no root colonization were detected in plant roots grown with *A. nicolsonii* and *S. fulgida* species. Single spores were then extracted from the substrate by the flotation-bubbling technique of Furlan and Fortin (1975). Spores and sporocarps were washed in water, surface sterilized in a chloramine-T 2% solution and submitted to a one-step freeze-drying of 4 hours (Dalpé, 1987).

Prior to lipid extraction, freeze-dried spores were kept 1h in sterile distilled water. Lipids were extracted from the spores by the method described by Kates (1972) for micororganisms, except that the extraction time was 6h instead of 2h. Saponification of the lipid, methyl ester preparation and gas chromatographic analyses of the total fatty acids were conducted as described previously (Weete et al., 1983). Spore samples (made of a minimum of 25 spores) were subjected to a comparative extraction by direct saponification with 3.3% KOH for 2h. Tentative identifications of the fatty acids in the form of their methyl ester derivatives were made by comparing their retention times relative to methyl behenate (C22:0) which was used as internal standard.

## RESULTS

Fatty acid composition of spores is shown in Table 1. The carbon chain length of identified fatty acids ranged from 14 to 22. Major saturated fatty acids in all the species studied were palmitic (C-16:0) and stearic (C 18:0) acids, together comprising from 25 to 55% of the total fatty acids. Myristic acid (C14:0) was also observed in all the species except in *S. fulgida*. Arachidonic acid (C20:0) was totally absent from all species. The odd-numbered fatty acid, margaric acid (C17:0), was detected in *G. mosseae* as in the *Glomus* sp. (YD586) which slightly resembles it in its morphology. Monounsaturated fatty acids were represented by both *cis* and *trans* isomers of the C16:1 and C18:1 fatty acids. Of the monoenes, oleic acid (C18:1 *cis*) dominated in all of the species except in *G. mosseae* and *G. versiforme* spores, where palmitoleic acid (C16:1 *trans*) comprised respectively 37 and 33% of the total fatty acids. Most of the *Glomus* species possessed only the *cis*-isomers of C16:1 and C18:1 fatty acids. *Acaulospora nicolsonii* contained exclusively *trans*-isomers of C16:1 and C18:1 acids whereas *G. intraradices* possessed both *cis* and *trans* isomers of the monounsaturated fatty acids (C16:1 and C18:1). Linoleic acid (C18:2) occurred in all the spore species except in *A. nicolsonii*. *Alpha* and *gamma* linolenic acid (C18:3 ω-3; C18:3 ω-6) were found in substantial amounts in *E. pisiformis*, together comprising almost 10% of the total fatty acids. *Acaulospora, Scutellospora, Glomus,* and *Sclerocystis* spore fatty acids contents were free of either linolenic acid isomer. Very long chain polyunsaturated fatty acids such as 11,14 Eicosadienoic acid (C20:2 ω-6), 8,11,14 Eicosatrienoic acid (C20:3 ω-6) arachidonic acid (C20:4 ω-6), 5,8,11,14,17 eicosapentaenoic acid (C20:5 ω-3), 4,7,10,13,16,19 docosahexaenoic acid (C22:6 ω-3) and some other unidentified polyenes were present in all the genera except *Endogone*. In the case of *G. macrocarpum*, about 50% of the fatty acids extracted from the spores are made up of the polyunsaturated C20 and C22 carbon chains.

## DISCUSSION

Because of the symbiotic mode of life of most of the fungal species studied, mass production of fungal spores has to be obtained by pot culture methods. For this reason, spore variations, particularly those related to spore maturity, level of dormancy, and environmental conditions during growth are all factors that may have had an influence on both the qualitative and quantitative content of fungal spore fatty acids. However, this study comprises the largest comparative survey of the fatty acid composition of endogonaceous and AMF spores.

## Similarities and differences between genera and species

The major fatty acids regularly found in fungi, C16:0, C16:1, C18:0, C18:1 and C18:2 (Weete, 1980 a,b; Lösel, 1988) are well represented in AMF and related species studied, comprising more than 80% of the total fatty acids. Shorter chain fatty acids characteristic of «Phycomycetes» (Brennan et al. 1974) are here represented by myristic acid (C14:0). Previous fatty acid analyses of *A. laevis* (Beilby, 1980), *G. caledonium* (Beilby & Kidby, 1980), *G. intraradices* and *G. margarita* (Jabaji-Hare, 1988) showed comparable results, except that the myristic acid content was not reported to be more than 0.6% of the total fatty acids.

All of the *Glomus* species studied have either palmitoleic (C16:1 *cis*), palmitelaidic (C16:1 *trans*) or both fatty acids. *Trans* isomers of C16:1 and C18:1 are reported here for the first time for endomycorrhizal fungi and related species. The *cis* configuration of the monounsaturated fatty acids is the one usually predominent in fungi (Brennan *et al.* 1974) while *trans*-monenes have rarely been reported in these organisms (Weete, 1980a).

No major differences in the fatty acid profiles were detected between species. The only exceptions are the absence of monounsaturated acids of the C16:1 group in *G. rubiforme*, the complete absence of polyunsaturated long chain fatty acid in *G. versiforme* and *Glomus* sp.(YD 586), and the net tendancy of *G. macrocarpum* to chain elongation and unsaturation. In the special case of *G. rubiforme*, results may have been altered by the fact that sporocarpic spores were extracted from the soil and may have been parasitized by bacteria even though they were carefully washed in several water baths.

The saprophytic species *Endogone pisiformis* differed considerably from the other studied species in the total absence of very long chain fatty acids and the simultaneous presence of ω-6 and ω-3 isomers of linolenic acid. *Acaulospora nicolsonii*, which has never been found colonizing leek roots, seems to be related neither to colonizing leek roots, seems to be related neither to *Glomus* nor to *Endogone* genera because its fatty acid content differed by both the absence of α and γ linolenic acids, and in the high content of palmitelaidic (C16:1 *trans*) and elaidic acid (C18:1 *trans*). The presence of an important C18:1 peak that posessed the same relative retention time (R.R.T.) as the elaidic acid standard seems to be highly characteristic of this fungus. *Scutellospora fulgida*, even if morphologically different from *Glomus* in its bulbous subtending hyphae, the absence of intraradical vesicles and its mode of germination (Walker & Sanders, 1986) has affinities with it in a very high palmitoleic acid content (22%), and some polyunsaturated very long chain fatty acids (C20:5 and C22:4). Its fatty acid profile is more comparable to that of *Glomus* species than of *A. nicolsonii* or *E. pisiformis*.

## Linolenic acids ω-3 and ω-6

In a general phylogenetic approach, ω-3 linolenic acid is synthetized by representatives of higher fungi whereas the ω-6 isomer is produced by lower fungi (Shaw, 1965; Nes & Nes, 1980; Weete, 1980a,b). In the few cases where both linolenic acid isomers have been detected in fungi, their distribution followed the phylogenetic pattern; for example, the ω-3 isomer predominated in Basidiomycetes (Rezanka & Mares, 1987) and the ω-6 isomer in Zygomycetes (Sumner, 1970; Sancholle, & Chavant, 1976; Chavant et al., 1979), Oomycetes (Manocha & Campbell, 1978), and Chytridiomycetes (Ellenbogen et al., 1969). *Endogone pisiformis* is the first reported endogonaceous species for which spores contain substantial amounts of both ω-3 and ω-6 isomers of linolenic acid, 10% of comprising total fatty acids. Nordby, *et al.* (1981), in their fatty acid analysis of *G. mosseae* spores, did not specify the presence of linolenic acid; otherwise only traces of ω-3 and ω-6 linolenic acid were detected in *A. laevis* (Beilby, 1980), *G. caledonium* (Beilby & Kidby, 1980), *G. mosseae* (Lösel, 1993, personal communication), *G. intraradices* and *Gi. margarita* spores (Jabaji-Hare, 1988), where linolenic acid content was virtually absent or never exceeded 0.5%. Compared to the fatty acid analysis previously done with somatic hyphae of *E. pisiformis* (Jabaji-Hare & al. 1988), where C18:3 ω-6 predominated, the accumulation of C18:3 ω-3 in the zygospores of this species may be considered one major transformation occurring in the differentiation and maturation of the thick-walled zygospores. The simultaneous absence, in *E. pisiformis*, of polyunsaturated very long chain fatty acids may also indicate the end-product status of linolenic acids in the zygospores.

## CONCLUSION

According to their fatty acid profiles, the genera studied here may be divides into three different groups: the zygosporic *Endogone pisiformis* on the basis of both α and γ linolenic acid; *Acaulospora nicolsonii*, characterized by the presence of monounsaturated fatty acids in *trans* configuration, palmitelaidic and elaidic acids and the AMF species including *S. fulgida* characterized by the absence of linolenic acid isomers and the presence of polyunsaturated very long chain fatty acids. The fatty acid analyses of other *Acaulospora* species, (as of spores of *Entrophospora* species), which belong to the family Acaulosporaceae would help to verify their eventual taxonomic relationships. In the light of these experiments, fatty acid analyses of AMF and Endogonaceae spores may provide generic and sometimes specific information about the symbiotic behaviour of AMF organisms. The convergences in the fatty acid composition between systematically related species can eventually be used as a tool for biochemical and morphological regrouping of related species and support general classification.

## ACKNOWLEDGEMENTS

We thank Dr J.D. Weete (Auburn University, Alabama) for providing us with technical facilities and for helpful discussions, Drs D. Lösel and C. Walker for the manuscript revisions; we are also grateful to C. Maître, G. Mitrow, and S. Gandhi for their scientific support.

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TABLE: 1: Percent total fatty acids of arbuscular mycorrhizal fungi and related species.

| Fatty acids | D/M[1] | 14:0 | 16:0 | 16:1 trans | 16:1 cis | 17:0 | 18:0 | 18:1 trans | 18:1 cis | 18:2 | 18:3 w-6 | 18:3 w-3 | 20:2 w-6 | 20:3 w-6 | 20:4 w-6 | 20:5 w-3 | 22:1 | 22:6 w-3 | Unidentified |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ENDOGONACEAE | | | | | | | | | | | | | | | | | | | |
| *Endogone pisiformis* | 0.79 | 7.9 | 26.99 | 7.4 | | | 13.90 | | 25.11 | 8.9 | 4.57 | 5.0 | | | | | | | |
| ACAULOSPORACEAE | | | | | | | | | | | | | | | | | | | |
| *Acaulospora nicolsonii* | 0.68 | 5.03 | 30.35 | 20.66 | | | 15.13 | 18.78 | | | | | | 1.68 | | 4.74 | | | 0.94 (1.13)[2] |
| GIGASPORACEAE | | | | | | | | | | | | | | | | | | | |
| *Scutellospora fulgida* | 1.09 | | 19.06 | 4.52 | 22.09 | | 10.15 | | 23.14 | 6.0 | | | | | | 9.49 | | | 5.54 (1.29) |
| GLOMACEAE | | | | | | | | | | | | | | | | | | | |
| *Glomus caledonium* | 0.63 | 7.62 | 17.76 | | 2.8 | | 24.10 | | 24.64 | 2.64 | | | 4.71 | | 2.12 | 1.86 | 7.23 | | 4.63(0.25) |
| *Glomus intraradices* | 0.85 | 3.13 | 32.96 | 7.97 | 8.36 | | 18.44 | 3.73 | 12.74 | 3.40 | | | | | | 9.25 | | | |
| *Glomus macrocarpum* | 2.62 | 6.00 | 14.43 | | 5.61 | | 10.34 | | 10.18 | 2.16 | | | 5.28 | 15.56 | | | | 30.80 | |
| *Glomus mosseae* | 0.78 | 4.84 | 20.35 | | 37.60 | tr. | 11.45 | | 14.36 | 2.69 | | | | | | 5.39 | | | 2.71(1.29) |
| *Glomus rubiforme* | 0.42 | 16.46 | 28.80 | | | | 26.91 | | 13.03 | 14.80 | | | | | | | tr. | | |
| *Glomus versiforme* | 0.41 | 4.68 | 36.83 | | 33.00 | | 18.79 | | 4.38 | 2.10 | | | | | | | | | |
| *Glomus* sp.(YD586) | 0.39 | 12.45 | 31.54 | 12.68 | | 4.53 | 16.50 | | 17.46 | 4.84 | | | | | | | | | |

1: D/M: Degree of fatty acids unsaturation.
2: Relative Retention Time (R.R.T.) standards.

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# DISCOSIA JORDANOVII, SP. NOV.

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**Abstract.** Discosia jordanovii - a new species of genus Discosia Lib. (Deuteromycotina, Coelomycetes), found on dead leaves of Robinia sp. in Italy is described and illustrated.

During a taxonomic revision of genus Discosia Lib.(Deuteromycotina, Coelomycetes) a herbarium specimen labelled "Discosia artocreas (Tode) Fr. f. robiniae"(unpublished name) received from Instituto de Botánica C. Spegazzini, La Plata, Argentina (LPS) was studied. The fungus found on dead leaves of Robinia sp. by Spegazzini in Italy, is a typical Discosia, belonging to Section Laurina Vanev (Vanev, 1991). In the present paper a new species is described, illustrated and compared with D. laurina Caldesi - a type species of the section.

**DISCOSIA JORDANOVII VANEV, SP. NOV.** (Fig. 1).

Pycnidia 100-245 µm in diam., suborbicularia vel angulata,irregularia, discoidea vel fere applanata, leviter papillata, epiphylla, nitido-nigra; ostiolis 22-40 µm in diam., rotundatis, centralis, leviter elevatis, cellulis intensius coloratis cincto. Cellulae conidiogenae 5-13 X 1.5-2.5 µm, cylindricae vel ampuliformes, interdum obtuso-conicae, rectae vel leviter curvatae, hyalinae. Conidia 11.3-15 ($\bar{x}$=13.33; S=1.17) X 2.5-3.3 ($\bar{x}$=2.88; S=0.23) µm, holoblastica, fusiformia, dorsiventralia, curvata, plus minusve arcuata, apice rotundata, basi truncata, 3-septata, ad septa non constricta, duae cellulae terminaliae parvae, fere triangulares, hyalinae, duae cellulae mediae magnae, fere aequilongae, subhyalinae vel flavido-viridae; appendiculae filiformiae, rectae vel leviter curvatae, proxime apicem basimque conidii formantur.

Typus: in foliis emortius *Robiniae* sp., Conegliano, Italia, January 1877, C. L. Spegazzini, ex Herb. La Plata sub *Discosia artocreas* (Tode) Fr. f. *robiniae* (LPS! **Holotypus**).

Conidiomata pycnidial, 100-245 µm in diam., subcircular or irregular in outline, discoid or sometimes flattened and slightly raised at the margin, epiphyllous, separate, black, shiny; ostioles 22-40 µm in diam., circular, central, slightly prominent, surrounded by a darker ring. Conidiogenous cells 5-13 X 1.5-2.5 µm, subcylindrical, flask-shaped or sometimes conical, straight or slightly curved, hyaline. Conidia 11.3-15 ($\bar{x}=13.33$; $S=1.17$) X 2.5-3.3 ($\bar{x}=2.88$; $S=0.23$) µm, holoblastic, fusiform, dorsiventral, more or less arch-shaped, tapered to the both ends, with a truncate base and an obtuse apex, clearly 3-septate, two end cells very short, almost triangular, hyaline, two middle cells nearly equal in length, much longer than the end cells, subhyaline or sometimes yellow-greenish; conidial appendages two, subapical and suprabasal, hair-like, lateral, hyaline, straight or slightly curved, arising just at the apical and the basal extremity of the ventral side of the conidium.

*D. jordanovii* looks like *D. laurina* (type species of Section Laurina) but clearly differs from that species in the size of pycnidia and conidia (Table 1).

## ACKNOWLEDGEMENTS

The author wishes to thank the Curator of LPS for the loan of the specimen examined.

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Vanev, S. G. 1991. Species conception and sections delimitation of genus *Discosia*. Mycotaxon 41:387-396.

Table 1. Comparative morphologic data of *Discosia jordanovii* and *D. laurina*

| Species | Diameter of pycnidia (μm) | Dimensions of conidia (μm) |
|---|---|---|
| *D. jordanovii* (type) | 100-245 | 11.3-15 ($\bar{x}$=13.33) X<br>2.5-3.3 ($\bar{x}$= 2.88) |
| *D. laurina* (type) | 210-360 | 15-20 ($\bar{x}$=17.76) X<br>1.8-2.5 ($\bar{x}$=2.13) |

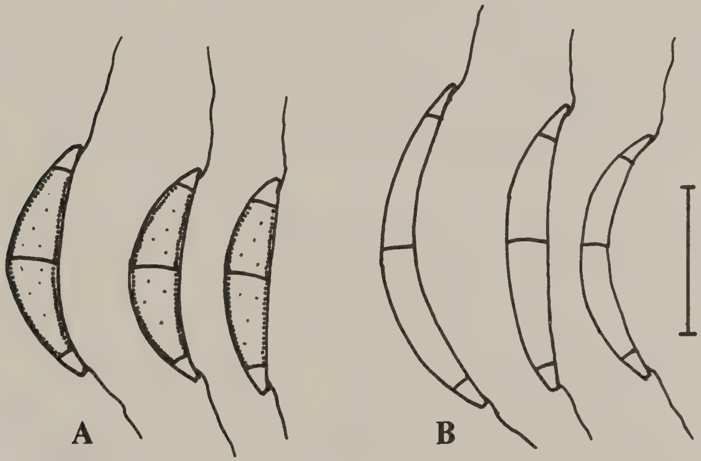

Fig. 1. Conidia of *Discosia jordanovii* (A) and *Discosia laurina* (B). Scale bar 10 μm.

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# MORPHOMETRIC VARIABILITY OF THE CONIDIA OF THE FUNGI FROM GENUS DISCOSIA SECTION STROBILINA

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ABSTRACT. Applying the variational-statistical analysis, an evaluation has been made of the morphometric variability of the length and the width of the conidia from type specimens of 14 taxa, belonging to Section *Strobilina* Vanev of the genus *Discosia* Lib. As a result of the study, 6 good species have been distinguished: *D. arxii* Vanev, *D. elliptica* Fres., *D. ostiolata* Berk. & Curt., *D. pleurochaeta* Durieu & Mont., *D. smilacina* De Not., *D. strobilina* Lib.

Belonging to Section *Strobilina* Vanev of genus *Discosia* Lib. are both plant parasites and saprotrophs. The distinguishing of the parasitic species in the classificational scheme we have created for the genus, respectively for Section *Strobilina*, has been made on the base of the parasitic specialization. The saprotrophic species within the limits ofthe section have been distinguished on the base of some morphological features of the conidia (length, width and shape).

The purpose of this study is to make an evaluation, using the variational-statistical analysis, with respect to the morphometric variability of the length and width of the conidia from the type specimens of the saprotrophic species belonging to Section *Strobilina*. As a result of data obtained, taxonomical conclusions are to be drawn related to the status of the taxa described so far.

## MATERIAL AND METHOD

The type specimens of 14 studied taxa, belonging to Section *Strobilina*, were obtained due to the responsiveness of the Curators in the following herbaria: AMH, BR, G, K, L, LPS, M, NYS, PAD, PC, PC, UPS, W.

For the purpose of this study, mixed samples were taken from completely mature conidia formed in normally developed pycnidia, collected from various parts of the specimen. Using standard methods, semistable lactophenol microscopic preparations with conidia were made from each specimen. Using an Amplival light microscope, measured were the length and the width of 50 conidia chosen at random.

Established in the variational analysis were: the limit values of the studied features (min-max); the average arithmetical value for each of the features ($\bar{x}$); the standard deviation (S); the variation coefficient (V). The rate of variability of the studied morphological features, shown by the variation coefficient, was defined after the method of Denchev (under print): reduced rate ($V \leq 5\%$); mean rate (modal level - $V=5.1-10\%$); raised rate ($V=10.1-15\%$) and high rate ($V=15.1-20\%$).

In the presence of numerical data from the average values, the standard deviation and the variation coefficient, showing a tendency towards a gradual increase with close-in-value levels (i.e. presence of continuity), we assume there is no discreteness in the studied morphological features, the discontinuance of the line of values being interpreted as a presence of discreteness in metrical aspect.

Comparing the studied type specimens, used was the linear graphical presentation of the stated statistical parameters from the various representative extracts. It was assumed, that the representative extracts are not discrete and the variability is continuous, in case there exists a graphical over lapping within range $\bar{x} \pm 1S$, the lack of one such overlapping therefore indicating the presence of discreteness among the compared specimens with respect to the studied features (Tibell,1980).

Established was the reliability of the differences between the average arithmetical values for the length and the width of the conidia in the specimen couples on the base of the reliability criterion (t) of Student.

## RESULTS AND DISCUSSION

MORPHOMETRIC VARIABILITY OF THE LENGTH OF THE CONIDIA. With respect to the length of the conidia, the studied specimens may be arranged into 3 groups: 1st one - *D. elliptica* and *D. arxii*; 2nd one - *D. strobilina*, *D. artocreas var. brasiliensis*, *D. syzygae*, *D. ostiolata*,

Table 1. Biometrical data of conidia from type specimens of the species belonging Section Strobilina

| Species | Statistical parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Length | | | | Width | | | | L/W |
| | min-max | $\bar{x}$ | S | V(%) | min-max | $\bar{x}$ | S | V(%) | |
| 1. D. artocreas (Tode) Fr. var. brasiliensis Speg. | 14-18.8 | 16.42 | 1.61 | 9.80 | 2.5-3 | 2.74 | 0.19 | 6.96 | 5.99 |
| 2. D. artocreas (Tode) Fr. f. camphorae Sacc. | 23.8-30 | 26-36 | 2.25 | 8.53 | 3-4 | 3.60 | 0.22 | 6.25 | 7.32 |
| 3. D. arxii Vanev | 11.3-14 | 13.04 | 1.16 | 8.89 | 2-2.5 | 2.26 | 0.20 | 8.95 | 5.76 |
| 4. D. blumencronii Bubák | 22.5-32.5 | 25.94 | 2.13 | 8.23 | 3.3-4 | 3.54 | 0.24 | 6.96 | 7.32 |
| 5. D. elliptica Fres. | 10-13.8 | 12.45 | 1.17 | 9.44 | 3-3.5 | 3.29 | 0.17 | 5.61 | 3.78 |
| 6. D. nitida Lév. | 15-21.3 | 17.47 | 1.71 | 11.73 | 3-3.8 | 3.32 | 0.20 | 6.07 | 5.26 |
| 7. D. ostiolata Berk.& Curt. | 15-18.8 | 16.61 | 1.52 | 9.19 | 3-3.8 | 3.20 | 0.23 | 7.43 | 5.19 |
| 8. D. pleurochaeta Dur.& Mont. | 22.5-30 | 26.20 | 2.21 | 8.46 | 3-4 | 3.54 | 0.27 | 7.83 | 7.40 |
| 9. D. rhododendri All. | 22.5-28.8 | 25.52 | 1.80 | 7.08 | 3.3-4 | 3.57 | 0.20 | 5.82 | 7.15 |
| 10. D. smilacina De Not. | 23.8-30 | 26.12 | 1.71 | 6.55 | 3.8-4.3 | 4.01 | 0.16 | 4.16 | 6.51 |
| 11. D. strobilina Lib. | 14-22 | 17.55 | 2.23 | 12.73 | 2.5-3 | 2.81 | 0.19 | 6.69 | 6.24 |
| 12. D. syzygae Mhask.& Rao | 15-21.3 | 18.18 | 1.56 | 8.60 | 2.5-3 | 2.64 | 0.20 | 7.48 | 6.88 |
| 13. D. vagans De Not. | 21.5-30 | 26.55 | 1.96 | 7.38 | 3.3-4 | 3.64 | 0.20 | 5.60 | 7.19 |
| 14. D. virginiana Thüm. | 14-20 | 17.09 | 1.90 | 11.12 | 2.5-3 | 2.71 | 0.20 | 7.48 | 6.30 |

D. nitida; 3rd one - D. pleurochaeta, D. artocreas f. camphorae, D. blumencronii, D. rhododendri, D. vagans, D. smilacina, with presence of discreteness among them in the variability of the average arithmetical values and the standard deviation. The conidia of the specimens in the 1st group are characterized by the smallest length, as to those of the specimens in the other two groups, both with respect to the measured limit values, and to the estimated average arithmetical value. Between the two representative extracts, belonging to this group, to be observed is a continuity in the variability of the studied statistical parameters (Fig. 1).

With the specimens in the second group there are certain differences in the metrical data for the length of the conidia, but it may be established on the base of Fig. 1, that there is a lack of discreteness in the variability of the average arithmetical values and the standard deviation, i.e. to be observed is a considerable overlapping within the zones $\bar{x}\pm1S$.

The representatives of the third group differ markedly from those of the other two groups - they are characterized by considerably loger conidida and by a wider span in the limit values of their length. Comparing the statistical parameters, we established that within the limits of the groups to be observed is a lack of discreteness in the variability of the average arithmetical values and the standard deviations of the individual specimens.

The data for the variation coefficient (Table 1) shows that in all studied specimens it is within the range of 6.55-12.73%. A considerable part of the specimens, belonging to all tree groups, are characterized by a mean rate of variability in the length of the conidia (modal level), while only in three specimens (D. strobilina, D. virginiana and D. nitida) the rate of variability is raised. No other rates of variability were established in the studied representative extracts (Table 2). The analysis of the variation coefficient shows that to be observed in the studied specimens is no discreteness with respect to this statistical parameter.

MORPHOMETRIC VARIABILITY OF THE WIDTH OF THE CONIDIA. Among all studied specimens, the lowest limit values (2-2.5 µm) and average arithmetical value ($\bar{x}$=2.26 µm) are to be observed with D. arxii. In this specimen a minimum width was measured - 2 µm - with no recorded values in its proximity, therefore we consider that value extreme. There is discontinuance in the variability of the studied statistical parameters between this representative extract and all rest (Fig. 1).

The widest are the conidia of *D. smilacina*, varying within the range 3.8-4.3 µm, where to be observed is discreteness of the average arithmetical value ($\bar{x}$=4.01 µm) and the standard deviation (S=0.16) in relation to the same parameters in all other specimens. In this representative extract measured was a maximum width of the conidia - 4.3 µm, regarded bu us as extreme.

The other studied specimens fall into two clearly differentiated groups: 1) *D. strobilina*, *D. artocreas* var. *brasiliensis*, *D. syzygae*, *D. virginiana*. 2) *D. elliptica*, *D. ostiolata*, *D. nitida*, *D. pleurochaeta*, *D. artocreas* f. *camphorae*, *D. blumencronii*, *D. rhododendri*, *D. vagans*, with a discontinued variability of the standard deviation and the average arithmetical values between the specimens of the two groups. In each group to be observed is a considerable graphical overlapping within the zone $\bar{x} \pm 1S$, on the base of which it may be concluded, that the representative extracts are not discrete.

The variation coefficient is within the range 4.16% (*D. smilacina*) to 8.95% (*D. arxll*). From Table 2 it is obvious that only in one representative extract (*D. smilacina*) the rate of variability is reduced, while in all rest it is within the range of modal level. The difference in the rate of variability in the studied specimens is insignificant. The distribution of the values is not of a discrete character.

Although the width of the conidia is a more constant feature as compared to the length, it is clear on the base of the data in Table 1 and Table 2, that the difference in the rate of variability between the two features is insignificant - in both cases considerably predominating are modal level values, while high variability was recorded im no representative extract, both with respect to the length and to the width of the conidia. Therefore, both features are taxonomically relevant and may be used in the elaboration of the classificational scheme of genus Discosia. On the same ground, wide is the application for distinguishing the species in our scheme, of the index for the shape of the conidia, showing the relation between the average values of the length and the width (L/W) for each representative extract. Comparing the indices gives an idea of the differences in the shape of the conidia of the studied specimens.

With respect to the index for the shape of the conidia, the specimens are as follows: 1) with short cylindrical, or short ellipsoidal conidia (L/W=3.78 - D. elliptica); 2) with protracted cylindrical, ellipsoidal, or fusoidal conidia (L/W=5.19-6.88 - D. artocreas var. brasiliensis, D. nitida, D. ostiolata, D. strobilina, D. smilacina, D. syzygae, D. virginiana); 3) with strongly protracted cylindrical, ellipsoidal, or fusoidal conidia (L/W=7.15-7.40 - D. artocreas f. camphorae, D. blumencronii, D. pleurochaeta, D. arxii, D. rhododendri, D. vagans).

TAXONOMIC CONCLUSIONS. The established differences of a discrete or non-discrete character among the studied 14 type specimens with respect to three morphological features of proved taxonomic relevance - length, width, and shape of the conidia, provide us grounds to reach upon the following decisions as regards the taxonomic status of those specimens:

1) D. arxii and D. elliptica are characterized by considerably shorter conidia as compared to all other specimens. With respect to the length of the conidia, the differences between the two representative extracts are of a continuous character. On the base of the statistically proved differences in the width of the conidia of D. arxii and D. elliptica, we consider that the two taxa have the right to exist independently.

2) The group of specimens with protracted cylindrical, ellipsoidal, or fusoidal conidia is characterized by a continuous variability of the average length of the conidia. Within its limits, two subgroups are to be formed with a discrete variability with respect to the width of the conidia. In the first one (D. artocreas var. brasiliensis, D. strobilina, D. syzygae and D. virginiana) the difference in the width of the conidia is insignificant (non-discrete), therefore we consider them belonging to one and the same taxon, the name of which, by priority, should be D. strobilina. D. ostiolata and D. nitida, forming the second subgroup, have statistically unproved differences in the width of the conidia and are two specimens of a species with a legitimate epithet D. ostiolata.

3) The specimens with strongly protracted cylindrical, ellipsoidal, or fusoidal conidia, differ markedly from the rest by their con-

siderably longer and wider conidia. Within this group only D. smilacina shoud be regarded as a good species, on the base of the established discreteness in the variability of the width of the conidia, while all other names (D. artocreas f. camphorae, D. blumencronii, D. rhododendri and D. vagans) ought to be considered synonymous to D. pleurochaeta (the oldest name).

Table 2. Distribution of the frequencies of the variation coefficients of the studied representative extracts

| Feature | Number of the studied representative extracts | Classes of the meaning of the variation coefficient of the representative extracts | | | |
|---|---|---|---|---|---|
| | | 5 | ≤5.1-10 | 10.1-15 | 15.1-20 |
| Length of the conidia | 14 | - | 12(86%) | 2(14%) | - |
| Width of the conidia | 14 | 1(7.2%) | 13(92.8%) | - | - |

## ACKNOWLEDGEMENTS

The author wishes to thank the Curators of : AMH, BR, G, K, LPS, M, NYS, PAD, PC, UPS, W for the loan of the type specimens examined.

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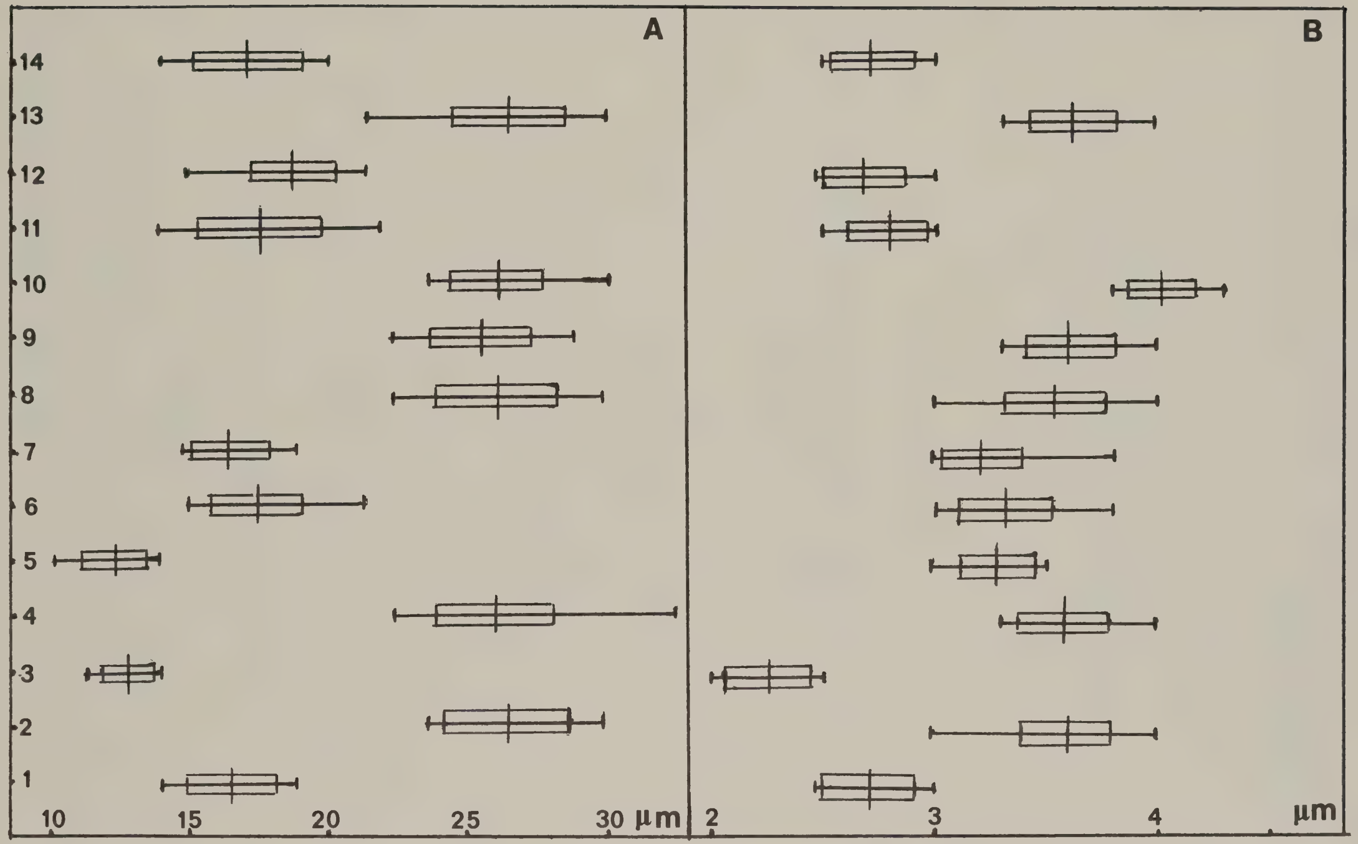
Fig. 1. Limit values, average arithmetical values and standard deviation of the length (A) and the width(B) of the conidia from 14 studied type specimens: 1. D. artocreas var. brasiliensis. 2. D. artocreas f. camphorae. 3. D. arxii. 4. D. blumencronii. 5. D. elliptica. 6. D. D. nitida. 7. D. ostiolata. 8. D. pleurochaeta. 9. D. rhododendri. 10. 11. D. strobilina. 12. D. syzygae. 13. D. vagans. 14. D. virginiana.


A
B
14
13
12
11
10
9
8
7
6
5
4
3
2
1
10
15
20
25
30 µm
2
3
4
µm

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# POLYPORES FROM BONIN IS. (JAPAN) I
# A NEW SPECIES OF INONOTUS (HYMENOCHAETACEAE, BASIDIOMYCOTINA)

by

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## SUMMARY

A new species of Hymenochaetaceae, *Inonotus boninensis*, is described from Bonin Is., Japan. It is characterized by a resupinate and woody basidiocarp, large colored spores, abundant setal hyphae, and absence of hymenial setae. Cultural characteristics are also described.

Key words : *Inonotus boninensis*, Hymenochaetaceae, polypores, Bonin Is.

## INTRODUCTION

Bonin Islands, one of Japan's subtropical regions, are situated about 1000 km south of Tokyo. Their flora is rather different not only from that of the Japanese mainland but also from that of other subtropical regions of Japan, and 71% of woody plants are endemic according to Toyota (1981).

The first report of polypores from the islands was that of Berkeley and Curtis (1860) based on collections by Charles Wright, later supplemented by a list of species published 118 years later by Pfister & Sayrc (1978). More species were published by Yasuda (1913a, b, c, 1914, 1916a, b, c, d, e) based on Lloyd's determinations (Lloyd 1912, 1915, 1916a, b, c) and by Ito and Imai (1940). However, the polypore flora of this area is still far from completely known.

One of us (T. H.) had an opportunity to visit the Bonin Islands during November 1990 and many polypores were collected. Among these was a resupinate *Inonotus* sp. with large colored spores and setal hyphae for which we could not find a published name. We conclude that it is undescribed and the name *Inonotus boninensis* is proposed.

## METHODS

The dried type specimen was studied both macroscopically and microscopically. Culture FFPRI-F-WD-850, isolated from decayed wood attached to type material, was grown on PDA (Eiken Chemical Co. Ltd.; 20 ml/plate) in 9-cm diam. glass Petri dishes. The relationship between temperature and mycelial growth rate was established by incubation at constant temperature at intervals of 3 °C from 4 to 40 °C. 5 replicates were prepared for each temperature. Mycelial growth rate, Kr, for each temperature was calculated using the following equation:

$$R_1 = R_0 + Kr\,(t_1 - t_0)$$

where $R_1$ = colony radius at time $t_1$, $R_0$ = colony radius at time $t_0$ (Trinci 1971).

The species code (Nobles 1965) was determined for 6-wk-old cultures. Extracellular oxidase reactions were tested according to the methods of Davidson et al. (1938), Nobles (1958), Käärik (1965), and Harkin et al. (1974).

Color of the basidiocarp and culture was described according to Kornerup and Wanscher (1981). The names of herbaria where specimens are deposited are abbreviated according to the Index Herbariorum, 8th edn.

## DESCRIPTION

***Inonotus boninensis*** Hattori & Ryvarden sp. nov.

Basidiocarpus resupinatus, poris brunneis, angulatis, 3-4 /mm, tubi brunnei, -8 mm longi, caro -0.5 mm, crassa, lignea. Systema hypharum monomiticum, hyphae 2.5-4 μm latae, hyalinae vel ferrugineae, setal hyphae multae, 10-25 μm latae, 100-300 μm longae in dissepimentis, -700 μm in caris, acutae, setae nullae, sporae ellipsoidae, 9.5-12 x 5-7.5 μm, hyalinae vel pallide flavibrunneae, non-amyloideae. Holotypus:

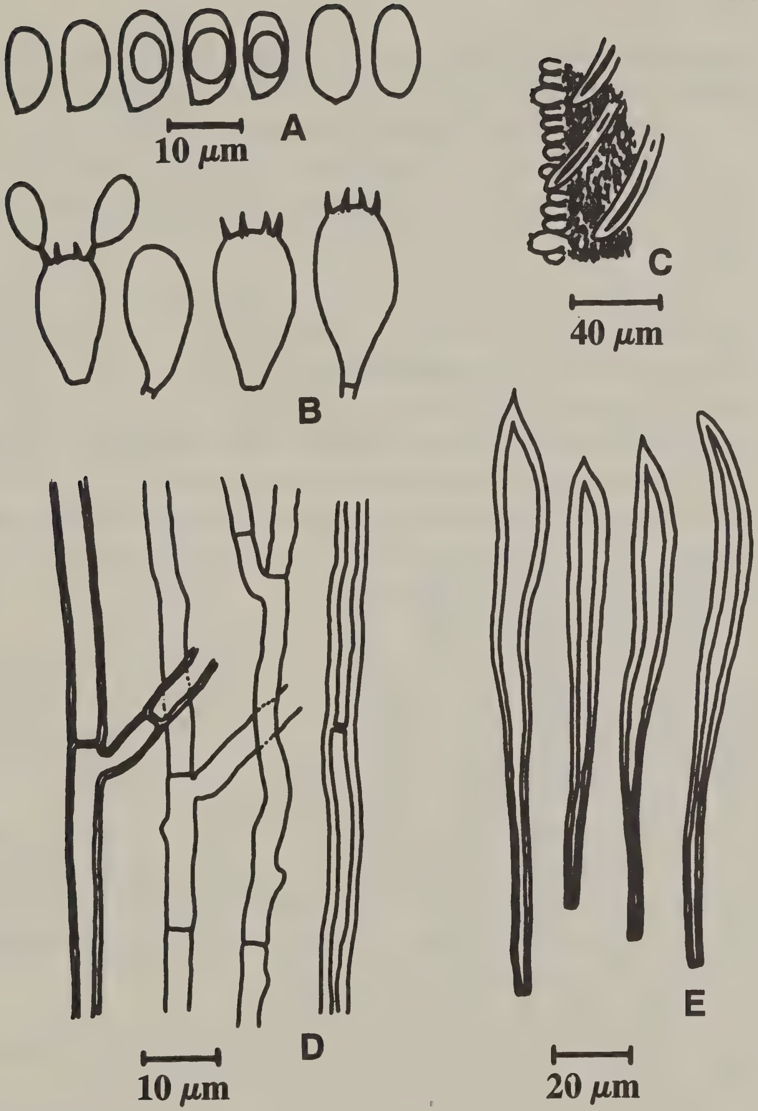
A
10 μm
B
C
40 μm
D
10 μm
E
20 μm

Fig. 1. *Inonotus boninensis*. Structures from basidiocarp. A, basidiospores; B, basidia; C, schematic drawing of hymenium and trama; D, generative hyphae; E, context setal hyphae.

Anijima Is., Bonin Is., Japan, ad truncum *Persea kobu* (Maxim.) Kosterm. (Lauraceae), leg. T. Hattori, 23 Nov. 1990, (TNS). Isotypi : O, K, BPI, TFM.

**Macroscopic and microscopic characteristics** (Fig. 1)

Basidiocarp resupinate and woody. Pore surface dark brown (6E6), pores angular, 3-4/mm, dissepiments thin to moderate, tubes up to 8 mm long, concolorous with pore surface. Context very thin, up to 0.5 mm wide, concolorous with pore surface.

Contextual hyphae monomitic, generative hyphae 2.5-4 $\mu$m wide, hyaline to rusty brown, walls up to 1 $\mu$m thick, moderately branched, without clamp connections. Setal hyphae abundant both in dissepiments and context, 10-25 $\mu$m wide, 100 to 300 $\mu$m long in dissepiments, up to 700 $\mu$m long in context, walls up to 3 $\mu$m thick, dark brown, pointed terminally; tramal setal hyphae mostly buried in the trama, rarely projecting into hymenium. Hymenial setae not seen. Basidia 15-22 X 7.5-10 $\mu$m, ellipsoid with base somewhat attenuated, 4- sterigmate, without a basal clamp. Spores ellipsoid, 9.5-12 X 5-7.5 $\mu$m (length / width : 1.5-2.0), hyaline to pale brown, IKI$^-$, with or without one oily drop in cytoplasm.

**Cultural characteristics**

Growth characteristics: The relationship between temperature and mycelial growth rate is shown in Fig. 2. Growth rapid (8.8 mm/day, 25 °C), optimum temperature 31°C, no growth occurred below 7 °C and above 37 °C. Advancing zone even, hyaline and appressed for short distance, then raised. Mat white, then orange white (5A2), felty to woolly. No fruiting was observed.

Microscopic characteristics (Fig. 3): Hyphae of advancing zone hyaline, branched, with simple septa, 1.5-5 $\mu$m wide. Hyphae of aerial and submerged mycelium of two kinds, (a) hyaline, branched, with simple septa, 1.5-5.0 $\mu$m wide, walls up to 1 $\mu$m thick; (b) setal hyphae rusty brown, rarely septate, 250-750 $\mu$m long, up to 12 $\mu$m wide, walls up to 5 $\mu$m thick, abundant .

Species code: 2, 6, 18, 32, 36, (37), 38, 42, 54.

Extracellular oxidase reactions: 0.5% gallic acid + (no growth); 0.5% tannic acid + ; gum guaiac + ; syringaldazine + ; $\alpha$-naphthol + ; p-cresol - ; tyrosine -

Culture examined: FFPRI-WD-850, isolated from the decayed wood attached to type material, deposited in FFPRI (For. For. Prod. Res. Inst., Tsukuba) and MAFF (Gene Bank, National Inst. Agrobiol. Resources, Tsukuba).

## DISCUSSION

*Inonotus boninensis* is characterized by its resupinate basidiocarp, abundant setal hyphae, large colored spores, and absence of setae. The spores are the largest

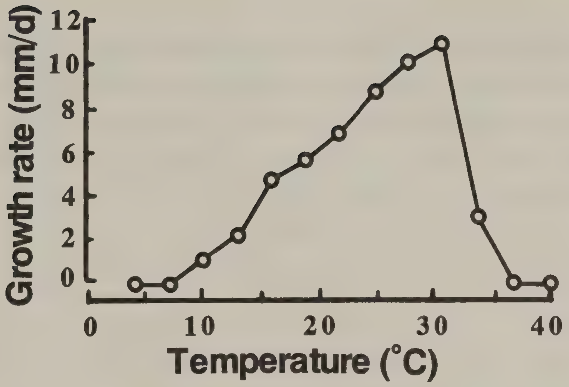

Fig. 2. Relationship between temperature and mycelial growth of *Inonotus boninensis*.

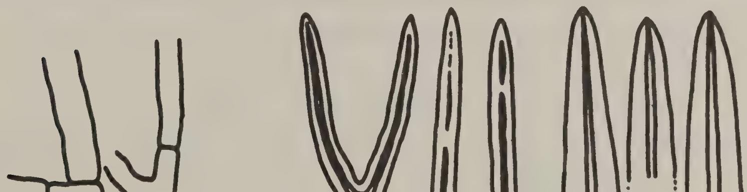

Fig. 3. *Inonotus boninensis*. Structures from culture. A, generative hyphae; B, C, setal hyphae.

known in *Inonotus* . *Inonotus micantissimus* (Rick) Rajch. from Brazil also has a resupinate basidiocarp, large colored spores and abundant setal hyphae. According to Rajchenberg (1987), however, *I. micantissimus* has hymenial setae, although their occurrence is rather scattered, and fine pores (7-9/mm). *I. boninensis* has no hymenial setae, and larger pores (3-4/mm), besides the spores of *I. boninensis* are ellipsoid while those of *I. micantissimus* are almost globose.

*Inonotus boninensis* has unusual cultural characteristics since setal hyphae are abundant in culture, and aerial mycelium remains almost white for a long time. Most Hymenochaetaceae species in culture have much darker colored aerial mycelium.

Optimum temperature for growth of *I. boninensis* is around 31 °C which suggests that it is adapted to a warm climate.

## ACKNOWLEDGMENTS

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# New tremellaceous fungi from Denmark

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## Abstract

The new genus *Renatobasidium* based on a new species, *R. notabile*, is described in Tremellales along with seven other new taxa of heterobasidiomycetes. In Auriculariales *Achroomyces insignis* sp. nov. is described and four new combinations proposed, viz.: *A. abditus* (Bandoni) Hauerslev comb. nov., *A. bisporus* (Hauerslev) Hauerslev comb. nov., *A. longisporus* (Hauerslev) Hauerslev comb. nov. and *A. subabditus* (Hauerslev) Hauerslev comb.nov. In Tremellales *Bourdotia galzinii* forma *microcystidiata* f. nov., *Exidiopsis citrina* sp. nov., *E. tenuis* sp. nov., *E. invasa* sp. nov., *Sebacina pulverea* sp. nov., *S. enodulosa* forma *tetraspora* f. nov. and *Stypella parvula* sp. nov. are described. The new taxa are illustrated with full drawings.

## Introduction

During the study of the resupinate heterobasidiomycetes mainly in the northern temperate deciduous forests of Denmark, a number of new species have been found and described (Hauerslev 1977, 1979, 1986, 1987, 1989). The present paper is a continuation of these studies describing a new genus and seven new species from different genera. Furthermore, a number of new species of *Myxarium* Wallr. have been dealt with in a semirevision of the genus in a separate paper (Hauerslev, in press).

The specimens were studied using light microscopy incl. phase–contrast. Dried material was cut with a razor–blade, and transferred to a drop of 3% KOH or ammonia. For staining, a number of reagents were used incl. e. g. phloxine, congored, cottonblue, rhodamine and Melzer's solution. The drawings were made with a camera–lucida. All the cited material are deposited in Copenhagen (C) unless otherwise stated.

In accordance with the synonymization by Donk (1966) of *Platygloea* Schroet. with the older *Achroomyces* Bonord., the following new combinations are proposed.

*Achroomyces abditus* (Bandoni) Hauerslev comb. nov.
Basionym: *Platygloea abdita* Bandoni, Mycologia 51: 94, 1959.

*Achroomyces bisporus* (Hauerslev) Hauerslev comb. nov.
Basionym: *Platygloea bispora* Hauerslev, Friesia XI: 331, 1987.

*Achroomyces longisporus* (Hauerslev) Hauerslev comb. nov.
Basionym: *Platygloea longispora* Hauerslev, Windahlia 16: 48, 1986.

*Achroomyces subabditus* (Hauerslev) Hauerslev comb. nov.
Basionym: *Platygloea subabdita* Hauerslev, Friesia XI: 329, 1987.

*Achroomyces insignis* Hauerslev n.sp. Fig. 1.
In fructificationibus *Myxarii* parasiticus. Hyphae hyalinae, tenuiter tunicatae, 1–1.5 µm latae, aut nodosae aut enodosae, cylindraceae vel breves, parenchyma formantes, chlamydosporas ferentes. Probasidia tenuiter tunicata, oblonga ad 9–14 × 5–7 µm. Metabasidia cylindracea 20–30 × 4–6 µm, transverse septata, 3–4–cellula, sterigmatibus usque ad 20 µm longis. Sporae hyalinae, subellipsoideae, basi attenuatae, 3.5–4 × 2–2.5 µm. Chlamydosporae leviter crassitunicatae, truncatae, 4–5.5 × 2.5–3 µm.
Holotype: Denmark, Hareskoven, 21.IX.1991, K. Hauerslev 7222.

Fruitbody growing on and in *Myxarium subhyalinum* (Pears.) Reid. Hyphae hyaline, thin–walled, 1–1.5 µm broad with or without clamp connections, cylindric or short–celled in parenchyma producing chlamydospores. Probasidia thin–walled, oblong, 9–14 × 5–7 µm. Metabasidia cylindric, 20–30 × 4–6 µm, transversely septate, 3–4–celled. Sterigmata up to 20 µm long. Spores subellipsoid, tapering towards apiculus, thin–walled, 3.5–4 × 2–2.5 µm. Chlamydospores somewhat thick–walled, 4–5.5 × 2.5–3 µm, truncate.
Notes: *Achroomyces insignis* is a parasite on *Myxarium* along with *A. subabditus* and *Achroomyces abditus*. However, it differs from both of these by the small spores and the presence of chlamydospores. Secondary spores have not been observed.

*Bourdotia galzinii* (Bres.) Trott. forma *microcystidiata* Hauerslev forma nov. Fig. 2.
Fructificatio resupinata, effusa, ceraceo–gelatinosa, siccitate dilute lutea vel obscure brunnea, vernicosa. Hyphae tenuiter tunicatae, plus minusve cylindraceae, noduloso–septatae, 1–4 µm diam. Hyphidia ramosa, 0.5–1.5 µm diam. Leptocystidia hyalinae, tenuiter tunicatae,

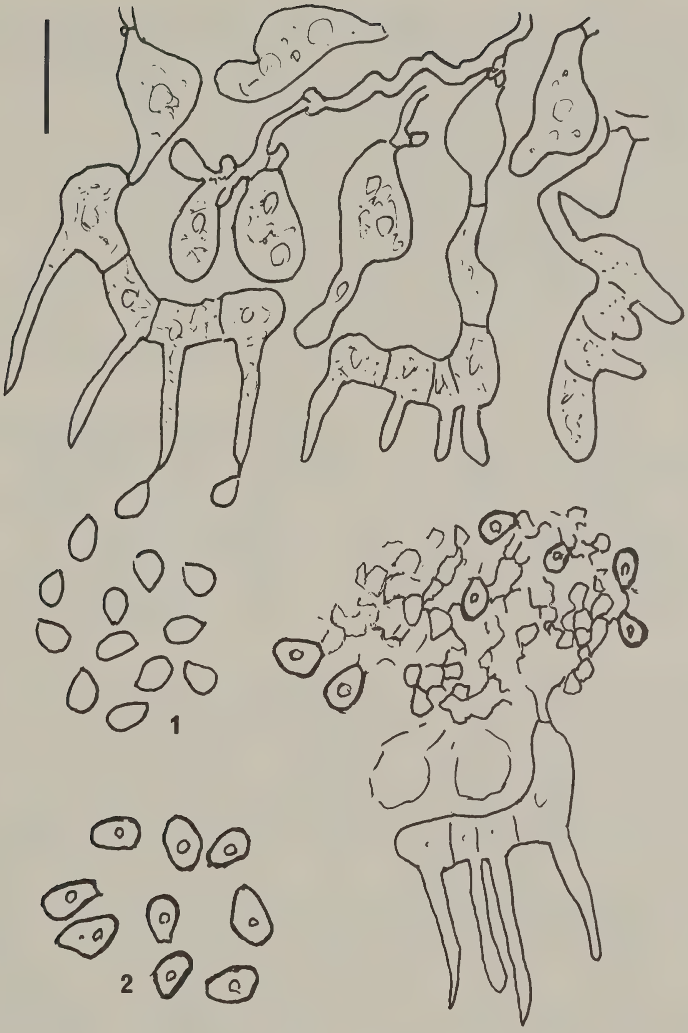

Fig. 1. *Achroomyces insignis*. Section of fruitbody (type). 1 = spores. 2 = conidia. Bar = 10 µm.

cylindraceo clavata vel flexuosa, 15–25(–30) x 4–8(–10) µm. Basidia subglobosa, interdum leviter petiolatae, cum fibulis basilaribus, longitudinaliter septata, 14–20(–25) x 11–14 µm, 2–4 sterigmatibus, ad 35 x 3 µm. Sporae subcylindraceae vel ovatae, hyalinae, tenuiter tunicatae, 9–14 x 4.5–7 µm, apiculatae.
Holotype: France; Bourdot 13956/Galzin 14319 (as *Sebacina mesomorpha* (PC)).

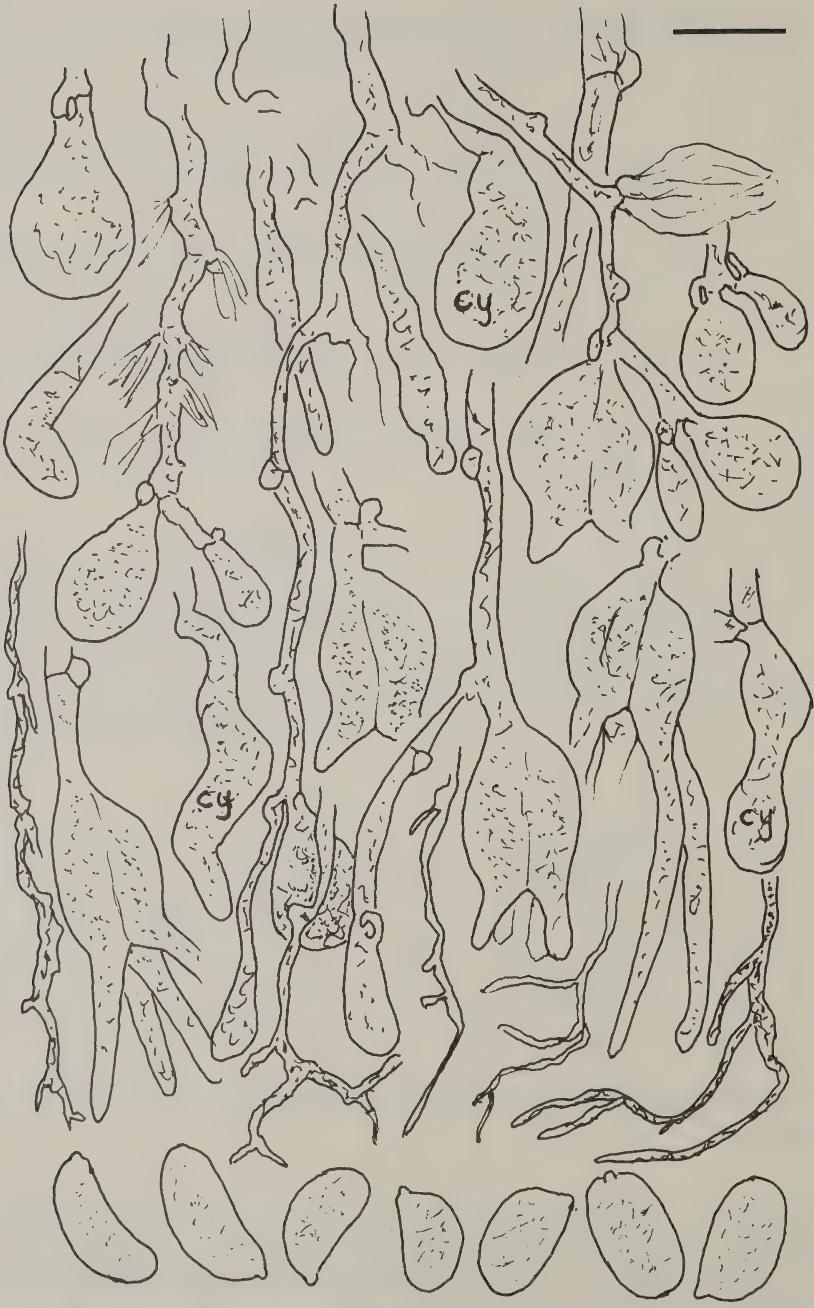

Fig. 2. *Bourdotia galzinii* forma *microcystidiata*. Section of fruitbody (type). Cy = leptocystidia. Bar = 10 µm.

Fruitbody resupinate, effused, waxy gelatinous, drying yellowish to dark brown, vernicose. Hyphae thin–walled, more or less cylindric, 1–4 μm broad, nodulose–septate. Hyphidia branched, 0.5–1.5 μm broad. Leptocystidia cylindric–clavate to sinuose, with hyaline contents, thin–walled, 15–25(–30) x 4–8(–10) μm. Basidia subglobose–ovoid, sometimes with cylindric base, with subbasidial clamp–connection, 14–20(–25) x 11–14 μm, 2–4–spored. Sterigmata up to 35 x 3 μm. Spores subcylindric somewhat flexuous to ovoid, hyaline, thin–walled, 9–14 x 4.5–7 μm, apiculate. Secondary spores not seen.

Notes: The only difference between this new form and *B. galzinii* forma *galzinii* is the leptocystidia, which are smaller and almost hyaline in the new form. The holotype was referred to *Exidiopsis laccata* by Luck–Allen (note in capsule). However, *E.* (*Myxarium*) *laccata* has no cystidia.

*Exidiopsis citrina* Hauerslev n.sp. Fig. 3.

Fructificatio gelatinosa, verruculosa, citrina, tenuis, siccitate evanida. Hyphae hyalinae, tenuiter tunicatae, nodoso–septatae, 1–2(–2.5) μm latae. Hyphidia 0.5–1.5 μm diam., simplicia vel ramosa. Basidia petiolata. Hypobasidia 6–10 × 5–6 μm, longitudinaliterque oblique septata, bispora. Sterigmata usque ad 30 μm longa. Sporae pyriformes vel ellipticae, hyalinae, tenuiter tunicatae, laeves, 6–7 × 3–4(–4.5) μm, apiculatae, per repetitionem germinantes.

Holotype: Denmark, Ørholm c. 10 km N of Copenhagen, on wood of ? Salix, 19.XI.1976, K. Hauerslev 5257.

Fruitbody gelatinous, yellowish, thin, warty, when dry almost invisible. Hyphae hyaline, thin–walled, with clamp connections, 1–2(–2.5) μm wide. Hyphidia simple or branched, thin–walled, 0.5–1.5 μm wide. Basidia petiolate, the stalk up to 35 μm long, terminal part 5–6 μm broad, obliquely and longitudinally septate, with 2 sterigmata up to 30 μm long. Spores pyriform to ellipsoid, smooth, thin–walled, hyaline, 6–7 × 3–4(–4.5) μm, apiculate, forming secondary spores.

Notes: The basidia show a tendency to split into two separate cells and young basidia are often considerably broader than mature ones. They are not myxarioid.

*Exidiopsis invasa* Hauerslev n.sp. Fig. 4.

Fungus parasiticus. Hyphae hyalinae, tenuiter tunicatae, 1–2 μm diam., noduloso–septatae. Haustoria adsunt. Leptocystidia hyalina, ventricoso–conica, 10–16 × 5–7 μm. Basidia globosa vel subglobosa, 6–7.5 μm diam., longitudinaliter septata, cum sterigmatibus 2–4, tenuibus, usque ad 22 μm longis. Sporae hyalinae, tenuiter tunicatae, laeves, subglobosae vel ellipsoideae, 3–4 × 2.5–3 μm, apiculatae.

Holotype: Denmark, Hareskoven, 5.X.1992, K. Hauerslev 7229, in *Trechispora microspora* (Karst.) Liberta.

Parasitic in *Trechispora microspora*. Hyphae hyaline, thin–walled, 1–2 μm broad, with clamp connections and haustorial branches from a clamp connection. Leptocystidia with hyaline contents, ventricose–conical, 10–16 × 5–7 μm.

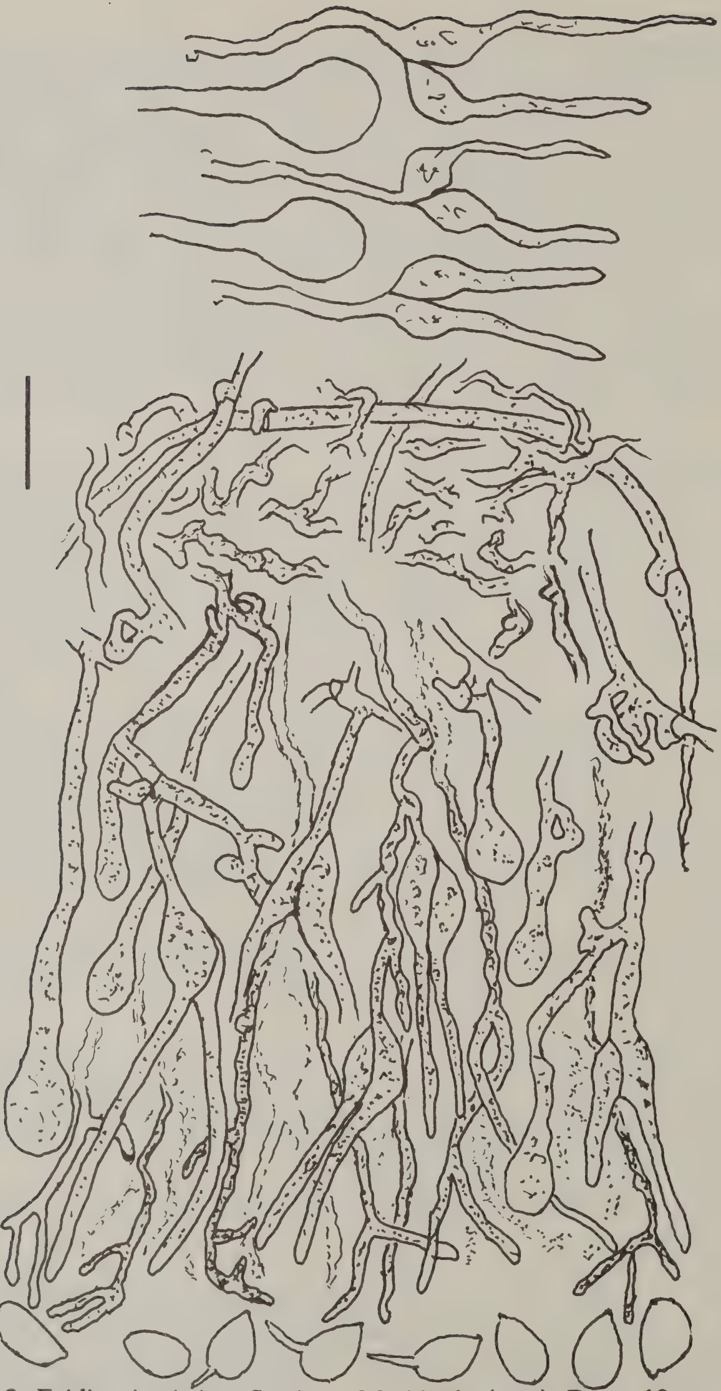

Fig. 3. *Exidiopsis citrina*. Section of fruitbody (type). Bar = 10 µm.

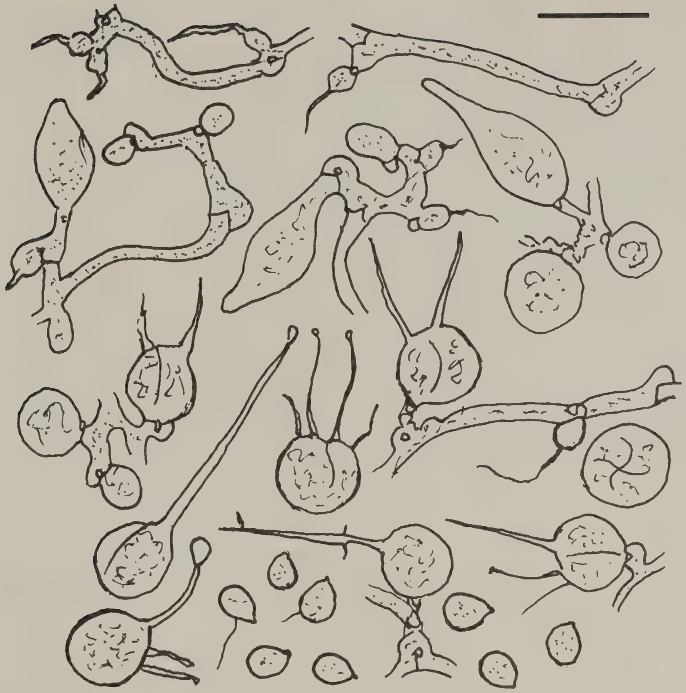

Fig. 4. *Exidiopsis invasa*. Section of fruitbody (type). Bar = 10 µm.

Basidia globose to subglobose, 6–7.5 µm diam., longitudinally septate, 2–4 thin sterigmata up to 22 µm long. Spores hyaline, thin–walled, smooth, subglobose to ellipsoid, 3–4 × 2.5–3 µm, with small apiculus.
Notes: *Botryobasidium subcoronatum* is also present in the typecollection, but the haustoria seem only to attach to the hyphae of the *Trechispora*.

*Exidiopsis molybdea* (McGuire) Ervin, Mycologia 49: 123, 1957 Fig. 5.
Basionym: *Sebacina molybdea* McGuire, Lloydia 4(1): 17, 1941.

Fruitbody gelatinous, drying vernicose to almost invisible. Hyphae thin–walled, with clamp connections, 1.5–3 µm diam. Hyphidia few. Basidia 2–4–celled, 8–15 x 8–12 µm, with sterigmata up to 40 µm long. Spores ovoid to ellipsoid or subcylindric, 9–13 x 5–8 µm.

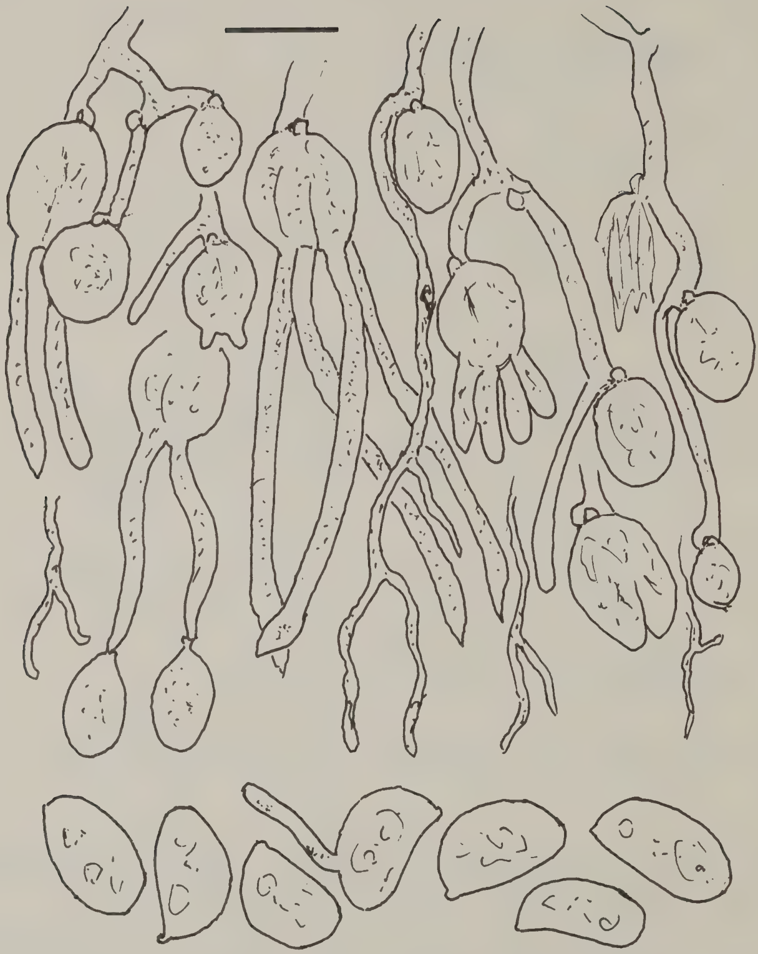

Fig. 5. *Exidiopsis molybdea*. Section of fruitbody (R.W.G. Dennis, Scotland, 25.VIII. 1963). Bar = 10 µm.

Material: Scotland: Furnace, Loch Maree, 22.VIII.1963, R.W.G. Dennis; Cudzon Park, 5.IX.1963, K. Hauerslev 3855; ibidem, 3870.
Notes: Some confusion exists over the relation between *E. molybdea* and *E. opalea*. McGuire (1941) described *E. molybdea* with spores 9–13.5 x 6–8.5 µm, thus separating it from *E. opalea* with spores 8–9 x 4.5–6 µm. Reid

(1970) after having studied part of the type–collection of *E. molybdea* with spores being 8.2–10.2 x 6.2–8 µm, concluded that the spore–size of *E. molybdea* falls within the range of *E. opalea*, by Bourdot & Galzin (1924) given as 7–11 x 5–7 µm. However, in authentic Bourdot & Galzin material at Kew, Reid (l.c.) found them to be 6.5–8 x 4.75–6 µm. Wells (1962) also separated the two taxa by the spore size, giving *E. opalea* (sub nom. *Exidiopsis glaira*) as 6–8(–10) x 4–6 µm and *E. molybdea* as (9–)10.5–19 x 5.5–8.5(–10). In material from Scotland collected by Dennis, Reid (l.c.) found the spores to be (8–)10–12 x 5–7.2 µm and concluded that it was *E. opalea* and put *E. molybdea* in synonymy, although with a question mark. The same collection was found by Martin (1952) to have spores 10–14 x 7–7.5 µm and by me to have spores 9–13 x 5–8 µm. The two Danish collections cited above have spores of the same size. Thus it seems that differences exists in the spore–size, even though there is some overlapping in the length. Until more material have been studied, preferably from spore–prints, I therefore follow McGuire, Martin and Wells and recognize the two species.

*Exidiopsis opalea* (Bourd. & Galz.) Reid, Fig. 6.
Trans. Brit. mycol. Soc. 55: 431, 1970.
Basionym: *Sebacina opalea* Bourd. & Galz., Bull. Soc. mycol. Fr. 39: 262, 1924.

Fruitbody gelatinous, drying vernicose to almost invisible. Hyphae thin–walled, with clamp connections, 1.5–2.5 µm broad. Hyphidia thin and few. Basidia with 2–4 sterigmata, 8–12 × (5–)7–10 µm, with clamp connections at the base. Spores ovoid–ellipsoid, 8–9 × 4.5–6(–7) µm.
Material: France, St. Sernin, XII.1915, on *Fraxinus*, Bourdot 16577/Galzin 19189 (K).
Notes: The Danish collection mentioned by Christiansen (1959: 29) is not *E. opalea*, but it has not been possible to identify it.

*Exidiopsis pulverea* Hauerslev n.sp. Fig. 7.
Fructificatio resupinata, tenuis, pulverea, albida, laxe adnata. Hyphae hyalinae, indistinctae, tenuiter tunicatae, obscure fibulatae, 0.5–1.5 µm latae. Leptocystidia hyalina, tenuiter tunicata, fusiformia, sparsa, laevia, 10–13 × 3.5 µm. Basidia acervata, ovata vel subglobosa, 9–12 × 7.5–9 µm, longitudinaliter septata, 2–4 sterigmata gerentia. Sporae hyalinae, tenuiter tunicatae, laeves, oblongae vel ellipsoideae, 8–14 × 3.5–5 µm, apiculatae, per repetitionem germinantes.
Holotype: Denmark, E–Jutland, Stagsrode Skov, 12.X.1963, on *Cryptomeria japonica*, K. Hauerslev 2209.

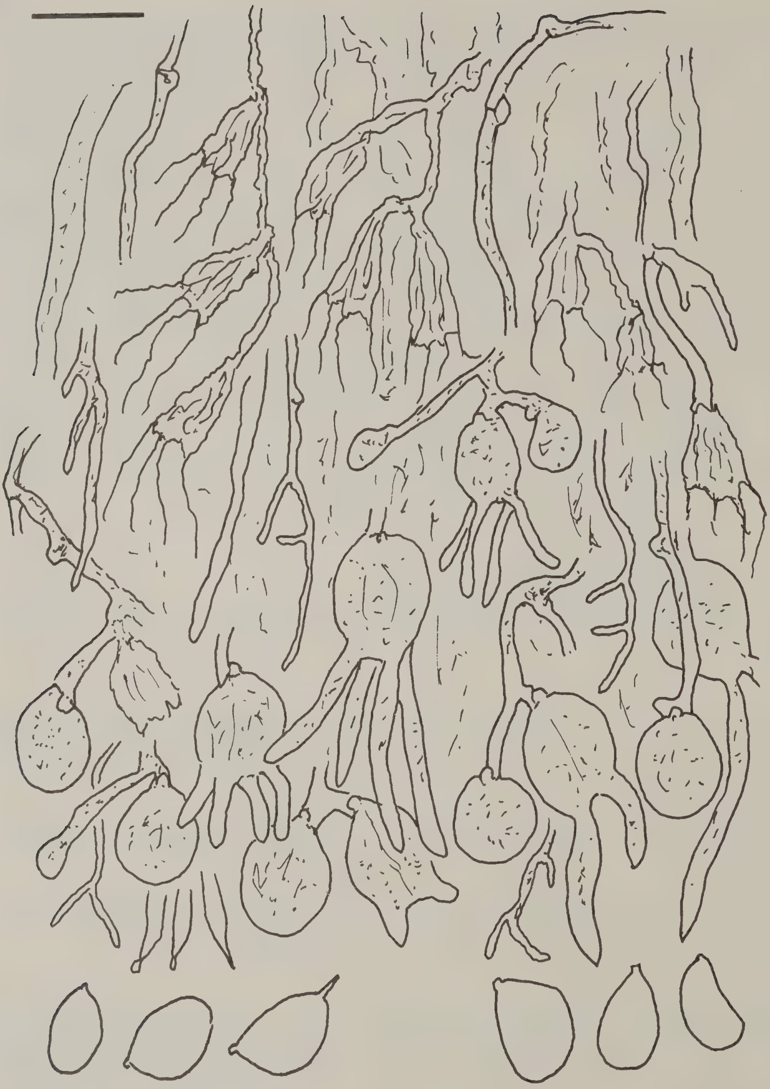

Fig. 6. *Exidiopsis opalea*. Section of fruitbody (Bourd.16577/Galz.19189 (K)). Bar = 10 µm.

Fruitbody thin, powdery, loosely adherent, whitish. Hyphae indistinct, hyaline, thin–walled, 0.5–1.5 µm broad, clamp connections small and indistinct. Leptocystidia few, fusoid, thin–walled, smooth, hyaline, 10–13 × 3.5 µm.

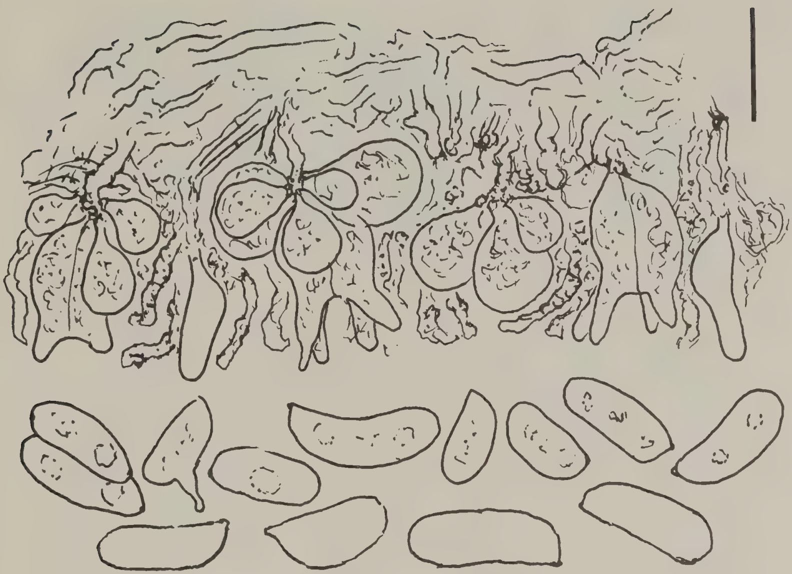

Fig. 7. *Exidiopsis pulverea*. Section of fruitbody (type). Bar = 10 µm.

Basidia in clusters, subglobose to ovoid, becoming 2–4–celled by longitudinal division, 9–12 × 7.5–9 µm. Sterigmata 5–8 µm long. Spores hyaline, thin–walled, oblong to ellipsoid, smooth, 8–14 × 3.5–5 µm, apiculate, forming secondary spores.
Other material: Denmark, Møn, Ulvshale, 20.X.1968, on *Pteridium aquilinum*, K. Hauerslev 3254.
Notes: This species is whitish powdery mainly caused by small crystals. Basidia are developed in closed formation in clusters.

*Exidiopsis tenuis* Hauerslev n. sp. Fig. 8.
Fructificatio tenuis, ceraceo–gelatinosa, effusa, grisea. Hyphae hyalinae, 1–2 µm diam., noduloso–septatae, tenuiter tunicatae, indistinctae vel cylindraceae. Hyphidia ramosa vel simplicia, 0.5–1 µm diam. Leptocystidia tenuiter tunicata, fusiformia, laevia, sparsa, 10–18 x 3–5 µm. Basidia subglobosa vel ellipsoidea, basi nodulosi–septata, 8–18 × 7.5–10.5 µm, longitudinaliter septata, 2 sterigmatibus 5–12 µm longis. Sporae subglobosae vel obovatae, tunicis tenuibus, laevibus, 7–8 × 5–6 µm, apiculatae, per repetitionem germinantes.
Holotype: Denmark, Holte, 20.V.1984, on wood, K. Hauerslev 6323.

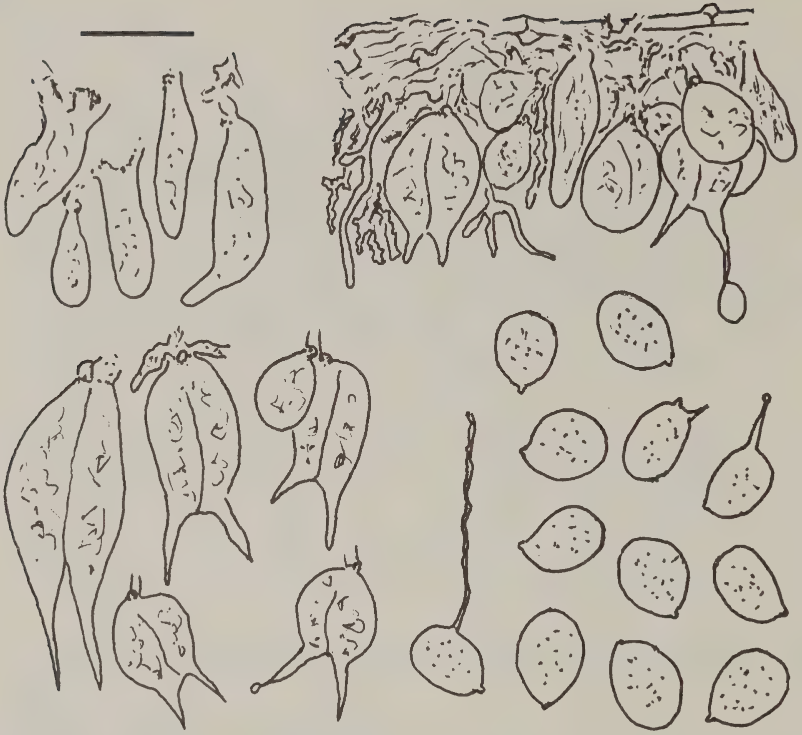

Fig. 8. *Exidiopsis tenuis*. Section of fruitbody (type). Bar = 10 µm.

Fruitbody thin, waxy–gelatinous, greyish, effused. Hyphae hyaline, indistinct or cylindric, thin–walled, 1–2 µm broad, clamp connections present. Hyphidia simple or little branched, 0.5–1 µm broad. Leptocystidia thin–walled, fusoid, smooth, 10–18 × 3–5 µm. Basidia hyaline, subglobose to ellipsoid, 8–18 × 7.5–10.5 µm, with clamp connections at base, by longitudinal division becoming 2–celled. Sterigmata 5–12 µm long. Spores subglobose to ovoid, thin–walled, smooth, 7–8 × 5–6 µm, apiculate, forming secondary spores.
Notes: This species is remarkable for its 2–spored basidia, leptocystidia and subglobose to ovoid spores.

*Renatobasidium* Hauerslev n. gen.

Genus Tremellacearum. Fructificatio resupinata. Hyphae enodulosae. Gloeocystidia adsunt. Basidia longitudinaliter septata, saepe per repetitionem formant. Sporae tenuiter tunicatae.
Typus generis: *Renatobasidium notabile* K. Hauerslev

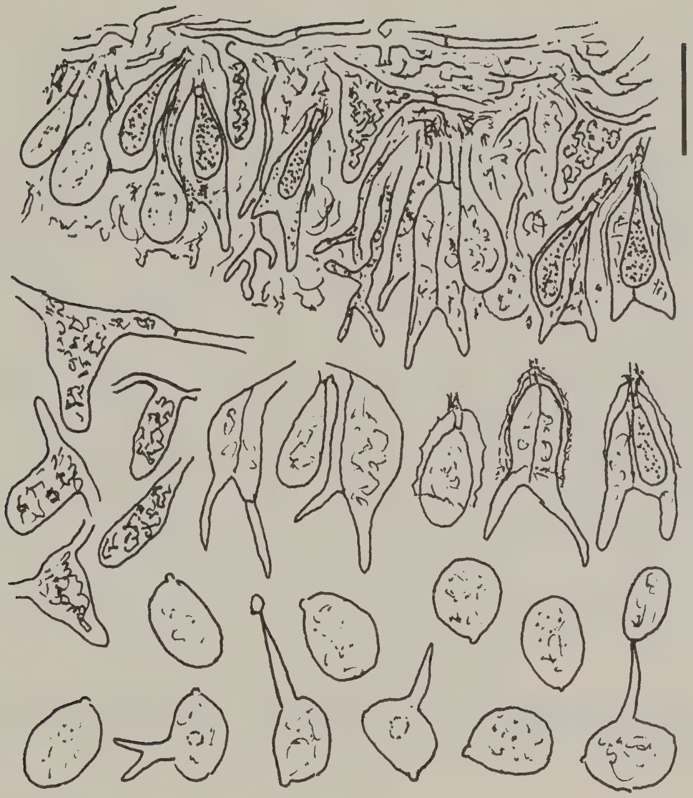

Fig. 9. *Renatobasidium notabile*. Section of fruitbody (type). Bar = 10 µm.

Fruitbody resupinate. Hyphae without clamp connections. Gloeocystidia present. Basidia longitudinally septate, often in linear formation. Spores thin–walled.

*Renatobasidium notabile* Hauerslev n.sp. Fig. 9.
Fructificatio tenuis, gelatinosa, siccitate pruinosa. Hyphae hyalinae, indistinctae, tenuiter tunicatae, 0.5–2 µm latae, enodulosae. Hyphidia ramosa. Gloeocystidia clavata vel conica, intus materia cremea vel brunnea, 8–13 × 3–6 µm. Basidia ovata, 7–13 × 5–7 µm, longitudinaliter septata, saepe per repetitionem formata, 2 sterigmatibus 6–10 µm longis. Sporae subglobosae vel obovatae, tunicis tenuibus, laevibus, 7–8(–9) x 5–6 µm, apiculatae, per repetitionem germinantes.
Holotype: Denmark, Sorgenfri, 24.V.1988, on ? Alnus, K. Hauerslev 6909.

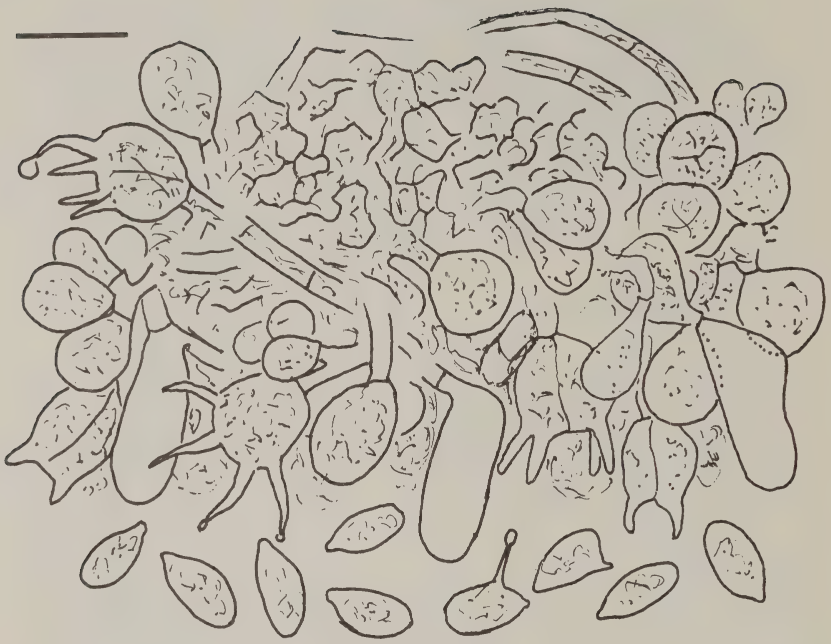

Fig. 10. *Sebacina enodulosa* forma *tetraspora*. Section of fruitbody (type). Bar = 10 µm.

Fruitbody thin, gelatinous, drying pruinose. Hyphae hyaline, indistinct, thin–walled, 0.5–2 µm broad, without clamp connections. Hyphidia few, little branched. Gloeocystidia clavate to conical, with light yellow to brownish contents, 8–13 × 3–6 µm. Basidia ovoid, 7–13 × 5–7 µm, often in linear formation, becoming 2–celled by longitudinal division. Sterigmata 6–10 µm long. Spores subglobose to ovoid, thin–walled, smooth 7–8(–9) x 5–6 µm, apiculate, forming secondary spores.

Other material: Denmark, Sorgenfri, 26.V.1988, K. Hauerslev 6911; ibidem, 2.VI.1988, K. Hauerslev 6924 and 6929; ibidem, 8.X.1988, K. Hauerslev 6949.

Notes: This species is remarkable for its basidia in linear formation. This character is also found in other genera, e. g. *Repetobasidium* J. Erikss. and *Repetobasidiellum* J. Erikss. & Hjortst. belonging to the Homobasidiomycetes, but *Renatobasidium* seems to be the first known genus with this character among the Heterobasidiomycetes.

*Sebacina enodulosa* Hauerslev forma *tetraspora* f. nov. Fig. 10.
Basionym: *Sebacina enodulosa* Hauerslev, Windahlia 16: 47–48, 1986.

Fructificatio tenuis, gelatinosa, siccitate grisea, farinosa. Hyphae hyalinae, tenuiter tunicatae, indistinctae vel cylindraceae, 1–3 µm latae, ad septa non nodosae. Leptocystidia tenuiter tunicata, subcylindracea, hyalina, 13–16 × 6–8.5 µm. Basidia subglobosa vel ovata, 7–10 × 6.5–8.5 µm, longitudinaliter septata, (2–)4 sterigmatibus 3–7 µm longis. Sporae hyalinae, ellipsoideae vel pyriformes, 6.5–8.5(–9) x 3.5–4(–4.5) µm, minute apiculatae, per repetitionem germinantes.
Holotype: Denmark, Hald, 28.IX.1975, on bark of ? *Ulmus*, K. Hauerslev 5003.

Fruitbody thin, gelatinous, drying mealy greyish, no margin. Hyphae hyaline, thin–walled, indistinct or cylindrical, 1–3 µm broad. Leptocystidia thin–walled, subcylindrical, hyaline, 13–16 × 6–8.5 µm. Basidia subglobose to ovoid, 7–10 × 6.5–8.5 µm, becoming (2–)4–celled by longitudinal division. Sterigmata 3–7 µm long. Spores hyaline, thin–walled, smooth, ellipsoid to pyriform, 6.5–8.5(–9) × 3.5–4(–4.5) µm, with small apiculus, forming secondary spores.
Other material: Denmark, Korsør Skov, 9.X.1965, on bark of *Fraxinus*, K. Hauerslev 5417; Copenhagen, Enceinten, 27.VIII. 1972, on wood of *Ulmus*, K. Hauerslev 4395; ibidem, 7.X.1972, on bark of *Ulmus* ?, K. Hauerslev 4431; ibidem, 4.XI.1972, on bark of *Ulmus* ?, K. Hauerslev 4457; Gallehus Skov, 21.X.1983, on bark of *Quercus*, K. Hauerslev 6280.
Notes: *Sebacina enodulosa* f. *tetraspora* resembles *Sebacina enodulosa* f. *enodulosa* which, however, is 2–spored and has larger spores, 9–11–13.5 × 4–5(–6) µm, and longer leptocystidia.

*Stypella parvula* Hauerslev n. sp. Fig. 11.
Fructificatio tenuis, gelatinosa, effusa, leviter tuberculosa, siccitata membranacea vel reticulata. Hyphae tenuiter tunicatae, 1–2.5 µm latae, nodoso–septatae. Hyphae apicis verrucae ca. 1 µm latae. Hyphidia ramosa, 0.5–1 µm lata. Leptocystidia cylindracea vel clavata, sinuoso–constricta, ad 30 × 5 µm. Basidia clavata, fibulata, 10–25 × 5–7 µm, 2 sterigmatibus usque ad 13 µm longis. Sporae hyalinae, laeves, ellipticae, tenuiter tunicatae, 6.5–10 × 4–6 µm, apiculatae, per repetitionem germinantes.
Holotype: Denmark, Kongelunden, 12.X.1980, on wood, K. Hauerslev 5920.

Fruitbody thin, gelatinous, effused, small warts with fimbriate top, drying membranaceous or reticulate. Hyphae thin–walled, with clamp connections, in the body 1–2.5 µm broad, in the top of the warts they are about 1 µm broad. Hyphidia branched, 0.5–1 µm broad. Leptocystidia cylindric to clavate with constrictions, up to 30 × 5 µm. Basidia clavate, 10–25 × 5–7 µm, with basal clamp connection, 2–celled. Sterigmata up to 13 µm long. Spores hyaline, smooth, thin–walled, 6.5–10 x 4–6 µm, ellipsoid, with small apiculus, forming secondary spores.

Notes: The fimbriate top of the small warts formed by thin hyphae and the 2–spored basidia are characteristic of this species. The direction of the septum formation in the basidia shows large irregularity.

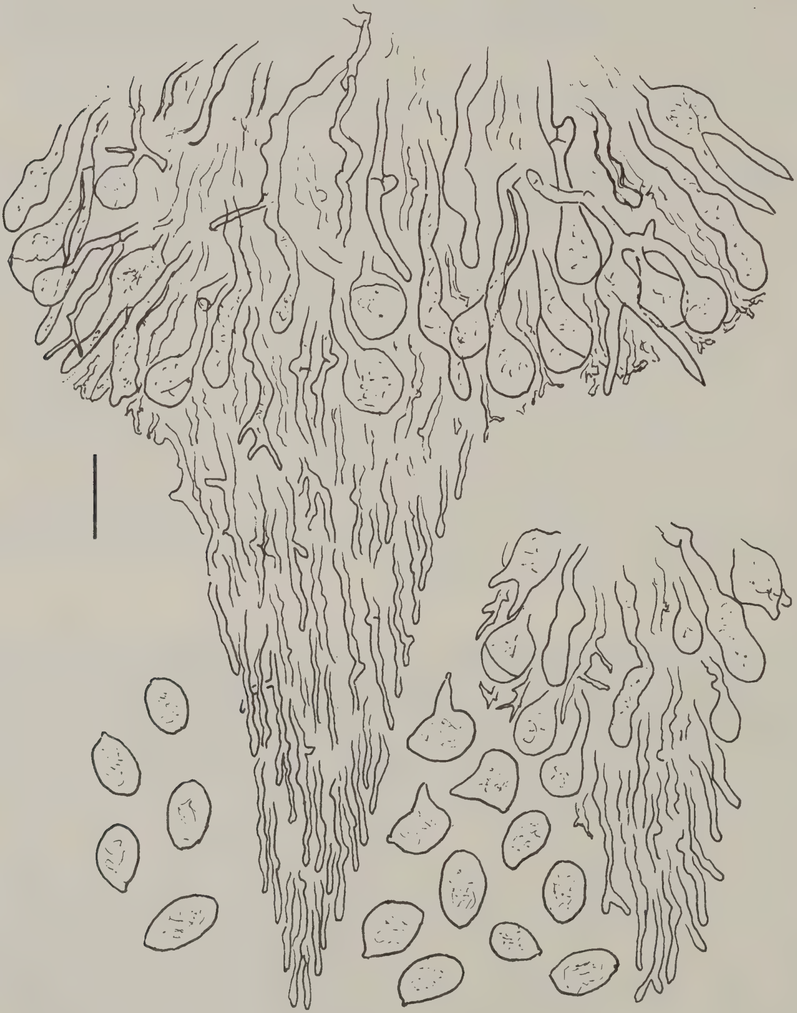

Fig. 11. *Stypella parvula*. Section of fruitbody (type). Bar = 10 µm.

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F. Oberwinkler (Tübingen) and H. Knudsen are warmly thanked for critically reading the manuscript, T. Christensen for checking the Latin diagnoses, H. F. Gøtzsche for technical help and the curators of C, K and PC for providing loans of material.

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# The genus *Myxarium* (Tremellales) in Denmark

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## Abstract

A survey of the genus *Myxarium* with special emphasis on the species occurring in Denmark is given. 12 taxa are described including five new species, viz. *M. gilvum* sp. nov., *M. granulum* sp. nov., *M. leptocystidiatum* sp. nov., *M. subgilvum* sp. nov., *M. varium* sp. nov, and a new form of *M. nucleatum* with broad ampullate hyphae, *M. nucleatum* f. *ampulligerum* f. nov. Type–material or other authentic material has been studied of *M. crystallinum*, *M. laccatum*, *M. sphaerosporum* and *Sebacina mesomorpha*. On the basis of this the new combination *Myxarium mesomorphum* is proposed. A key and full drawings of all the species are provided.

## Introduction

The genus *Myxarium* was established by the German mycologist Wallroth in 1833 with one species, *M. nucleatum*. Wells (1964) described the specific sphaero–pedunculate basidium with a globose part separated from a stipe part with a septum but without the formation of a clamp–connection later termed "myxarioid" by Donk (1966). Donk also listed the synonyms and misapplications, accepting only one species in Europe, *M. hyalinum* (Pers.) Donk, for what is here called *M. nucleatum*. Reid (1970) transferred two species into *Myxarium*, and later (Reid, 1973) he described a new one and transferred two more. Finally Raitviir (1971) described a new species and transferred another one into the genus. Jülich (1984) gave a key to the eigth known European species.

The specimens were studied using light microscopy incl. phase–contrast. Dried material was cut with a razor–blade, and transferred to a drop of 3% KOH or ammonia. For staining, a number of reagents were used incl. e. g. phloxine, congored, cottonblue, rhodamine and Melzer's solution. The drawings were made with a camera–lucida. All the cited material are deposited in Copenhagen (C) unless otherwise stated.

Key to Danish species of *Myxarium*

1. All basidia 2–spored . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. Basidia 2– or 4–spored . . . . . . . . . . . . . . . . . . . . . . . . 5
2. Fruitbody in a firm mucous embedment dissolving in sulphuric acid, forming small brownish oily drops . . . . . . . *M. granulum*
2. Sulphuric acid not necessary to dissolve fruitbody–embedment . 3
3. Fruitbody of small gelatinous grains drying whitish reticulate . . . . . . . . . . . . . . . . . . . . . . . . . *M. crystallinum*
3. Fruitbody yellowish, drying to a hyaline–vernicose film, sometimes loosening from the substrate . . . . . . . . . . . . . . . . 4
4. Spores 7–13(–14) x 4–6.5 µm . . . . . . . . . . . . . . . . *M. gilvum*
4. Spores 6–9 x 4–6 µm . . . . . . . . . . . . . . . . . . . . *M. subgilvum*
5. Hyphae irregular, up to 6 µm broad . . . . . . . . . . . . *M. varium*
5. Hyphae more or less regular . . . . . . . . . . . . . . . . . . . . 6
6. Spores globose to subglobose . . . . . . . . . . . . . . . . . . . 7
6. Spores ellipsoid to cylindric . . . . . . . . . . . . . . . . . . . . 8
7. Leptocystidia present, up to 35 x 4 µm . . . *M. leptocystidiatum*
7. Leptocystidia absent or very small . . . . . . . . *M. sphaerosporum*
8. Spores 6–9.5(–10) x 3–4(–4.5) µm . . . . . . . . . . . . . . . . . 9
8. Spores 9–15 x 4–8.5 µm . . . . . . . . . . . . . . . . . . . . . . . 12
9. Leptocystidia present . . . . . . . . . . . . . . . . . . . . . . . . 10
9. Leptocystidia absent . . . . . . . . . . . . . . . . . . . . . . . . . 11
10. Leptocystidia 30–60 x 4–7 µm, emergent; spores 6.5–8 x 3–4 µm . . . . . . . . . . . . . . . . . . . . . . . . . . *M. subhyalinum*
10. Leptocystidia up to 40 x 15 µm, not emergent; spores 7–8(–9) x 3–4.5 µm . . . . . . . . . . . . . . . . . . . . . . . . *M. vernicosum*
11. Fruitbody of small gelatinous grains, not or hardly confluent. Spores 6–7(–10) x 3–4(–4.5) µm . . . . . . . . . . . . . . *M. grilletii*
11. Fruitbody even, coherent. Spores 7.5–9.5 x 3–4 µm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *M. podlachicum*
12. Spores ellipsoid to cylindric; ampullate hyphae absent . . . . . . 13
12. Spores cylindric to allantoid; ampullate hyphae present . . . . . 14
13. Spores 11.5–15 x 5–8.5 µm (not in Denmark) . . . . *M. laccatum*
13. Spores 9–14 x 4.5–6 µm . . . . . . . . . . . . . . *M. mesomorphum*
14. Fruitbody widely effused. Ampullate hyphae to 3 µm wide . . . . . . . . . . . . . . . . . . . . . . . . . . *M. nucleatum* f. *nucleatum*
14. Fruitbody discrete, forming yellow, semiglobose pustules on pyrenomycete. Ampullate hyphae to 6(–7) µm . . . . . . . . . . . . . . . . . . . . . . . *M. nucleatum* f. *ampulligerum*

*Myxarium crystallinum* Reid, Persoonia 7: 293, 1973. Fig. 1.
Fructification a thin gelatinous film with small pustules drying to a whitish reticulum (sub lente). Hyphae indistinct, hyaline 0.5–1.5 µm broad, with clamp connections. Hyphidia few. Basidia myxarioid, apical part 6–8 × 5–7 µm, 2–spored. Spores ellipsoid to ovoid, 6–9 × 4–5.5 µm, forming secondary spores.
Type: Great Britain, Vann Lake, Ockley, Surrey, 22.X.1972, Petch (K, Type).
Other material: Denmark: Sjælland, Ørholm, 24.7.1967, K. Hauerslev 2770.

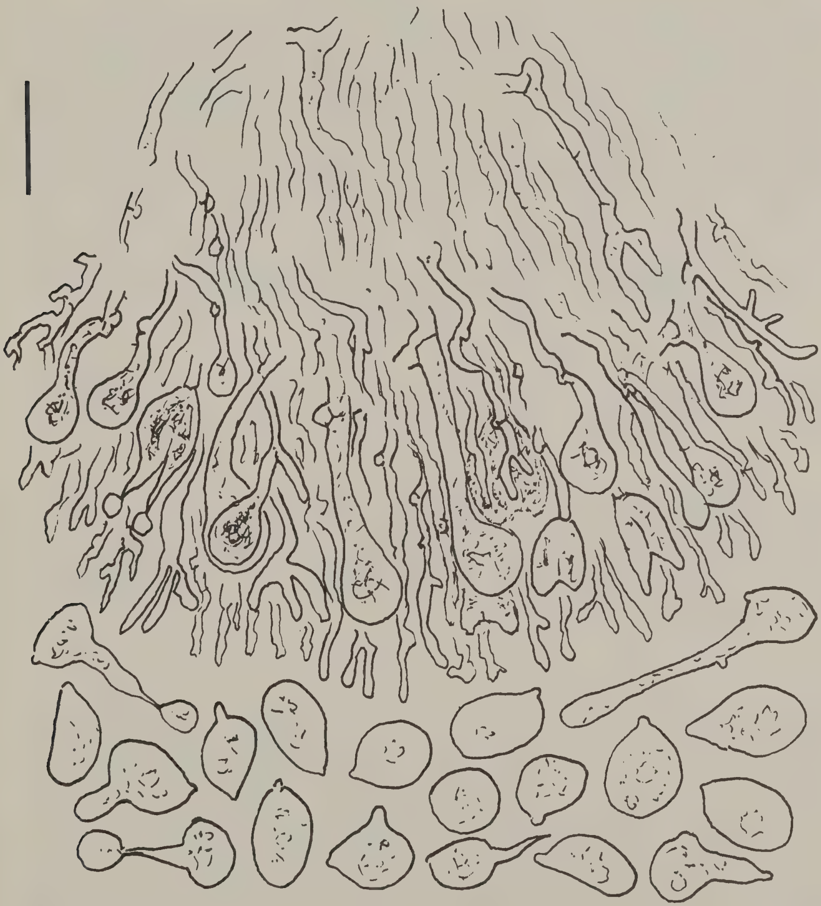

Fig. 1. *Myxarium crystallinum*. Section of fruitbody (type). Bar = 10 µm.

*Myxarium gilvum* Hauerslev n.sp. Fig. 2.
Fructificatio tenuis, gelatinosa, griseo–hyalina vel lutea, siccitate vernicoso–membranacea vel reticulata. Hyphae in parte indistinctae, tenuiter tunicatae, fibulatae, 1–2 µm diam. Hyphidia 0.5–2 µm latae, ramosa. Basidia myxarioidea, usque ad 30 µm longa, capitibus 7–10 x 6–8 µm, 2–sterigmatibus usque ad 25 µm longis. Sporae ovatae vel ovoideae (6–)7–13(–14) × 4–6.5 µm, hyalinae, tunicis tenuibus laevibus, apiculatae, per repetitionem germinantes.
Holotype: Denmark, Ørholm c. 10 km N of Copenhagen, 19.XI. 1976, on wood, K. Hauerslev 5264.

Fruitbody thin, greyish hyaline to yellowish gelatinous, verruculose, drying to a hyaline–vernicose film, more or less reticulate, sometimes loosening from the substrate. Hyphae thin–walled, rather indistinct, 1–2 µm broad, with clamp connections. Hyphidia 0.5–2 µm wide, branched. Basidia of the myxarioid type, up to 30 µm long, the head 7–10 × 6–8 µm, becoming 2–celled by longitudinal division. Sterigmata up to 25 µm long. Spores ovoid to ellipsoid, (6–)7–13(–14) × 4–6.5 µm, hyaline, thin–walled, smooth, apiculate, forming secondary spores.
Notes: *Myxarium gilvum* is apparently related to *M. crystallinum*, but differs by drying to a yellowish, irregular film, sometimes loosening from the substrate and with somewhat broader spores and hyphidia.

*Myxarium granulum* Hauerslev n.sp. Fig. 3.
Misapplication: *Sebacina sphaerospora* Bourd. & Galz. sensu M. P. Christiansen, Dansk Bot. Arkiv 19: 29, 1959.

Fructificatio gelatinosa, minute pustulata, effusa, tenuis, siccitate evanida. Hyphae conglutinatae, omnino indistinctae, 1–2 µm latae, nodulosae. Hyphidia simplicia vel ramosa, ad 1 µm diam. Basidia myxarioidea, usque ad 26 µm longa, capitibus 8–10 × 5–8 µm, 2–sterigmatibus usque ad 11 µm longis. Sporae subglobosae aut pyriformes, tenuiter tunicatae, hyalinae, 5–7.5 × 4.5–6 µm, apiculatae.
Holotype: Denmark, Zealand, Korsør, 4.VIII.1958, on *Betula*, K. Hauerslev 7250.

Fruitbody resupinate, effused, hyaline–bluish, consists of minute gelatinous pustules, non–continuous, visible under a lens, invisible on drying. Hyphae and basidia are imbedded in a firm mucus, and only after treatment with strong sulphuric acid these elements can be clearly seen. Hyphae thin–walled, 1–2 µm broad with clamp connections. Hyphidia simple or branched, about 1 µm broad. Basidia myxarioid, up to 26 µm long, the "head" 8–10 × 5–8 µm, becoming 2–celled by longitudinal division. Sterigmata up to 11 µm long. Spores thin–walled, hyaline, pyriform to subglobose, 5–7.5 × 4.5–6 µm, apiculate, secondary spores not seen.

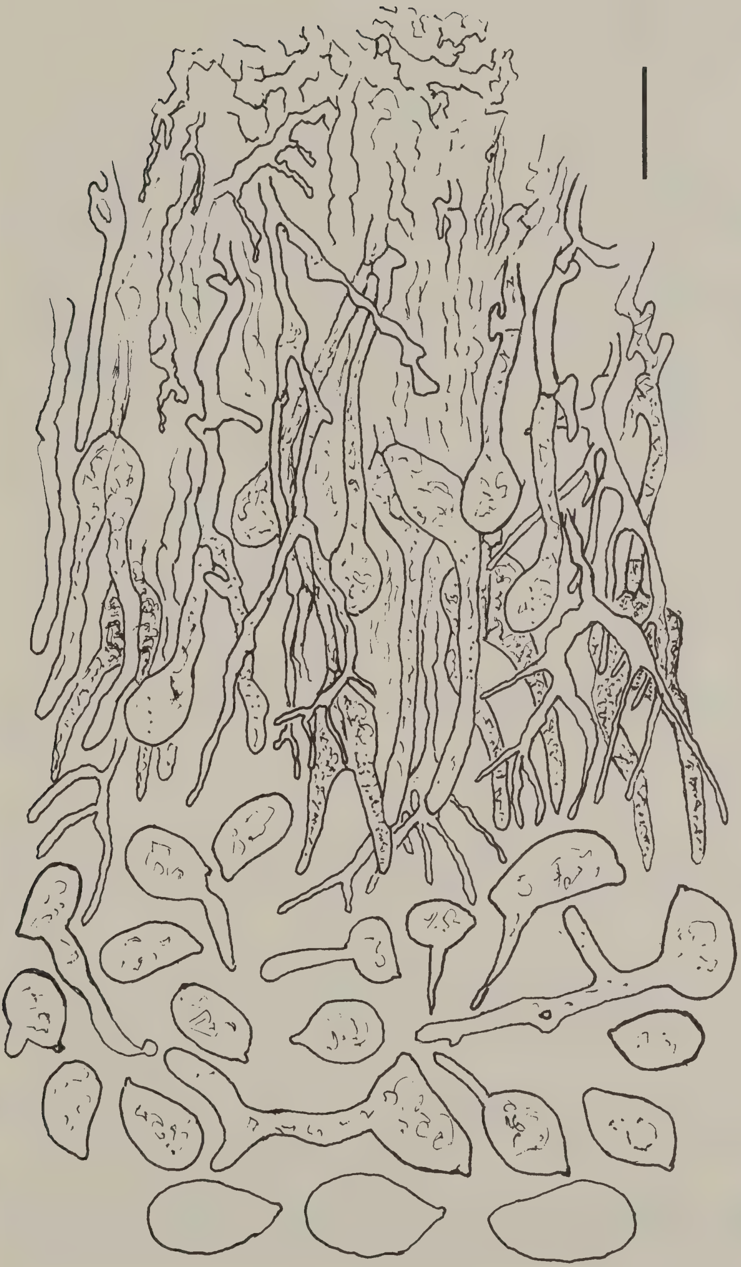

Fig. 2. *Myxarium gilvum*. Section of fruitbody (type). Bar = 10 µm.

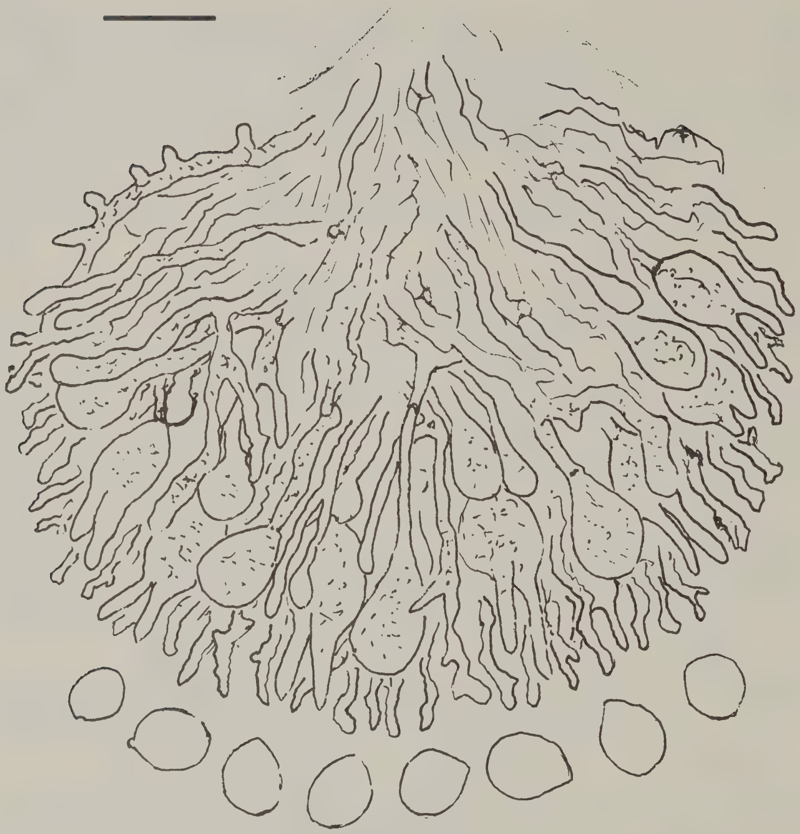

Fig. 3. *Myxarium granulum*. Section of fruitbody (type). Bar = 10 µm.

Notes: Characteristic of this species is the firm mucus–embedment that dissolves in sulphuric acid forming small brownish oily drops. After neutralizing with ammoniumhydroxide and colouring, the hyphae and basidia are visible.

*Myxarium grilletii* (Bourd.) Reid, Persoonia 7: 297, 1973 Fig. 4.
Basionym: *Tremella grilletii* Bourd., Bull. Soc. bot. Fr. 32: 284, 1885.

Fruitbody of densely crowded small papillae (warts), gelatinous, drying almost invisible. Hyphae indistinct, 0.5–2 µm, with clamp connections. Hyphidia

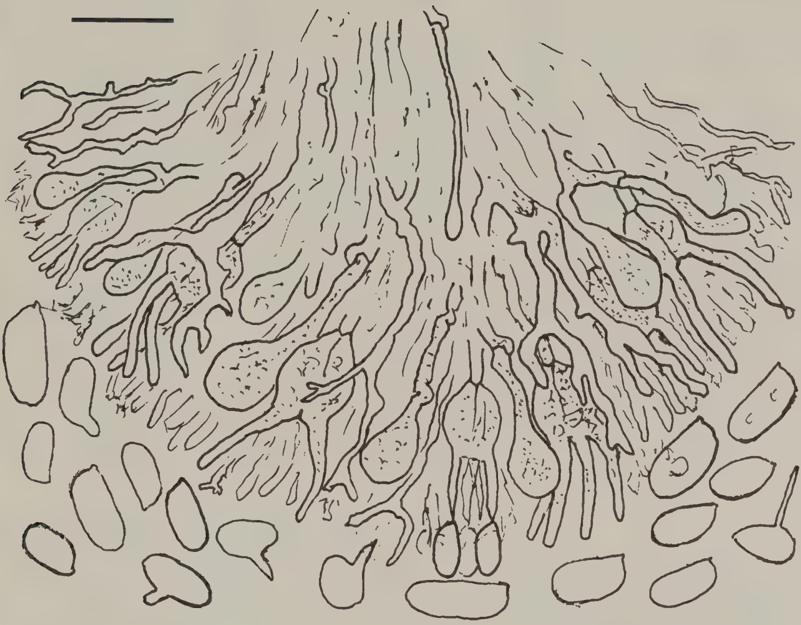

Fig. 4. *Myxarium grilletii*. Section of fruitbody (K. Hauerslev 6360). Bar = 10 µm.

simple or branched, 0.5–2.5 µm broad. Basidia myxarioid, the apical part 6.5–9.5 × 5.5–7 µm, longitudinally septate, with 2–4 sterigmata. Spores ellipsoid to subcylindric, 6–7(–10) × 3–4(–4.5) µm, with small apiculus, forming secondary spores.
Material: Denmark, Holte c. 17 km N of Copenhagen, 7.IX.1984, on wood, K. Hauerslev 6360; Great Britain, Berredale, Hoy, Orkney, 9.IX.1988, on *Betula*, R.W.G. Dennis.

*Myxarium laccatum* (Bourd. & Galz.) Reid Fig. 5.
Basionym: Sabacina laccata Bourd. & Galz., Bull. Soc. mycol. Fr. 39: 262.

Fruitbody gelatinous, drying vernicose.
Hyphae thin–walled, 1–3 µm, with clamp–connections. Hyphidia cylindric to clavate, with thin branches at the apex. Basidia myxarioid, 13–20 x 9–11

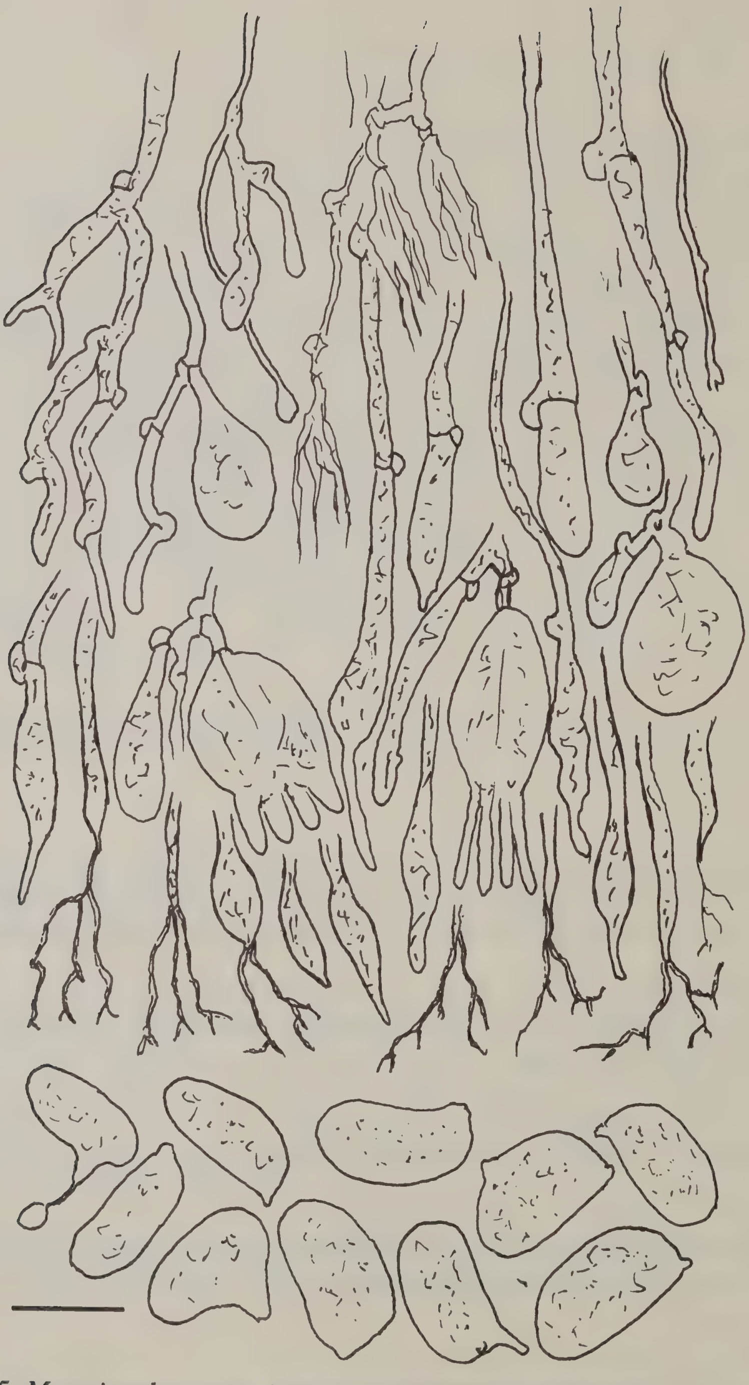

Fig. 5. *Myxarium laccatum*. Section of fruitbody (lectotype). Bar = 10 µm.

μm, with 2–4 sterigmata. Spores ellipsoid to ovoid, 11.5–15 x 5–8.5 μm, forming secondary spores.

Lectotype (here selected): Herb. Bourd. 7199/Galz. 5743, Champignons de l'Aveyron, l'Hospitalet (Larzac) sur pin, 25.4.1910.

Notes: When asking for type material of this species in PC, two authentic collections, both named *Sebacina laccata* were received. One of them is in close agreement with the description of this species by Bourdot & Galzin, and is selected as the lectotype. The other collection (Bourd. 19694/Galz. 21736) is *Myxarium nucleatum*.

Neuhoff (1936) suggested that *M. laccatum* was a large–spored form of *M. mesomorphum*. Luck–Allen on the contrary (in Wells 1962) suggested that *M. mesomorphum* was a synonym of *M. laccatum*, a view also taken by Wells after having studied authentic material of both species from PC. Although some overlap exists in the spore–size, it seems as if the material still can be separated into two groups, and the two species are therefore still recognized here.

*Myxarium leptocystidiatum* Hauerslev n.sp. Fig. 6.

Fructificatio effusa, tenuis, gelatinosa, siccitate ochraceo–vernicosa vel evanida. Hyphae hyalinae, tenuiter tunicatae, 0.5–2 μm latae, noduloso–septatae. Hyphidia simplicia vel ramosa. Leptocystidia clavata vel cylindracea, usque ad 35 × 4 μm. Basidia myxarioidea usque ad 30 μm longa, capitibus 6.5–9 × 5–8 μm, longitudinaliter septatis, (2–)4–sterigmatibus, 5–17 μm longis. Sporae globosae vel subglobosae, laeves, tenuiter tunicatae, 4–5.5 × (3–)3.5–5 μm, apiculatae, per repetitionem germinantes.

Holotype: Denmark, Ørholm c. 10 km N of Copenhagen, 9.X.1982, on wood, K. Hauerslev 6197.

Fruitbody effused, thin, gelatinous, drying ochraceous–vernicose or evanescent. Hyphae thin–walled, hyaline, 0.5–2 μm wide, provided with clamp connections. Hyphidia simple or branched. Leptocystidia clavate to cylindric, up to 35 × 4 μm. Basidia myxarioid, up to 30 μm long, the "head" 6.5–9 × 5–8 μm, becoming (2–)4–celled by longitudinal division. Sterigmata 5–17 μm long. Spores globose to subglobose, smooth, thin–walled, 4–5.5 × (3–)3.5–5.5 μm, apiculate, forming secondary spores.

Other material: Denmark, Djursland, Emmedsbo Plantage, 22.VII.1964, on *Picea*, K. Hauerslev 2205.

Notes: *Myxarium leptocystidiatum* is closely related to *M. sphaerosporum*, but is provided with leptocystidia.

*Myxarium mesomorphum* (Bourd. & Galz.) Hauerslev comb. nov. Fig. 7.

Basionym: *Sebacina mesomorpha* Bourd. & Galz., Bull. Soc. mycol. Fr. 39: 262.

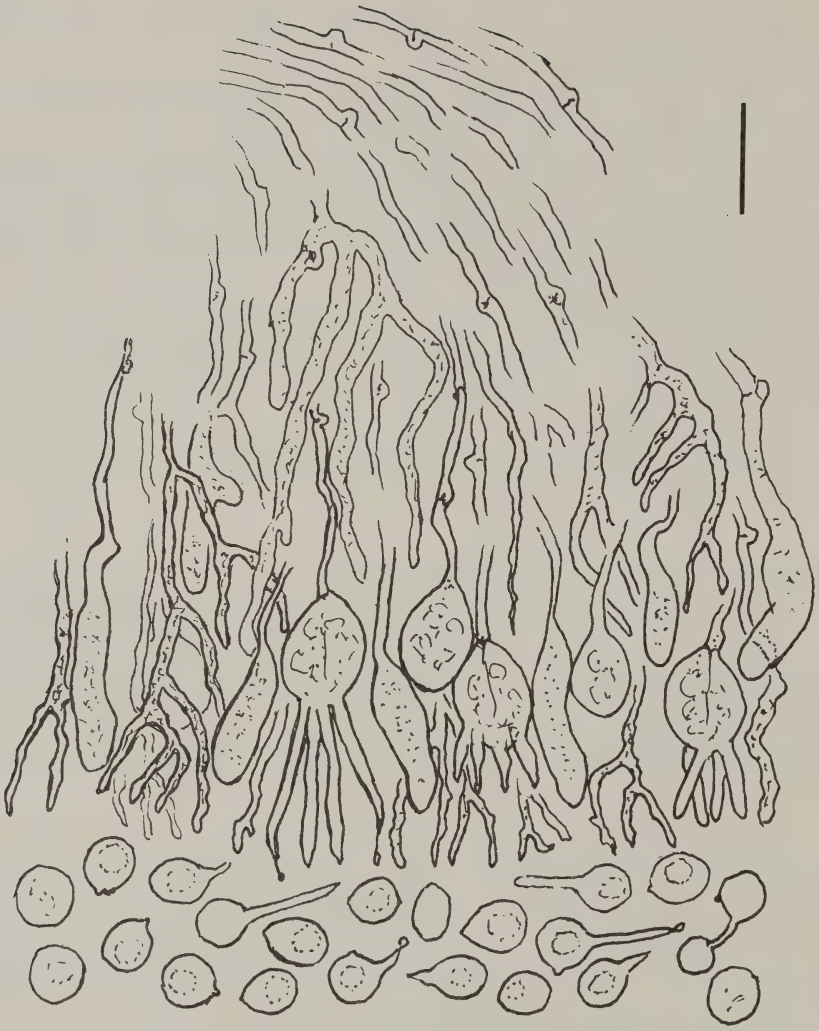

Fig. 6. *Myxarium leptocystidiatum*. Section of fruitbody (type). Bar = 10 µm.

Fruitbody gelatinous drying vernicose. Hyphae thin–walled, 1–2.5(–3) µm broad, with clamp connections. Hyphidia 0.5–2 µm. Basidia myxarioid. The "head" 15–20 × 9–14 µm, with 2–4 sterigmata. Spores ellipsoid to allantoid, 9–14 × 4.5–6 µm, forming secondary spores.

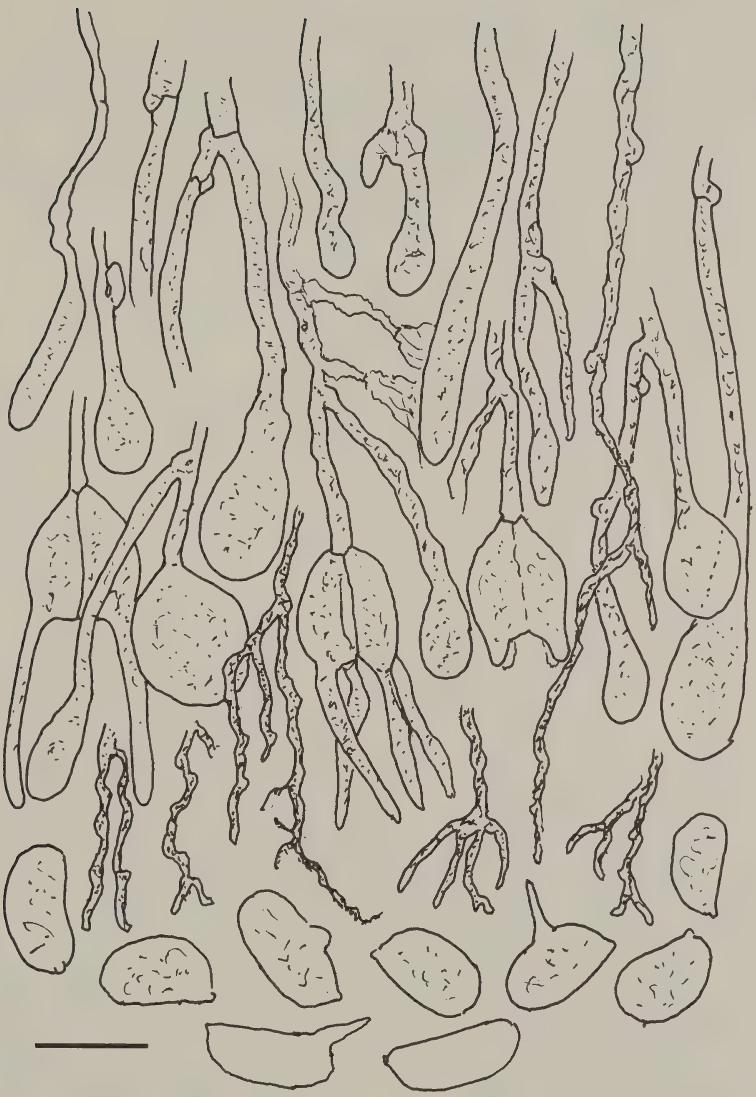

Fig. 7. *Myxarium mesomorphum*. Section of fruitbody (lectotype). Bar = 10 µm.

Lectotype (here selected): Bourdot 13949/Galzin 15287 (PC). Syntype: Bourdot 13928/Galzin 15223 (PC).

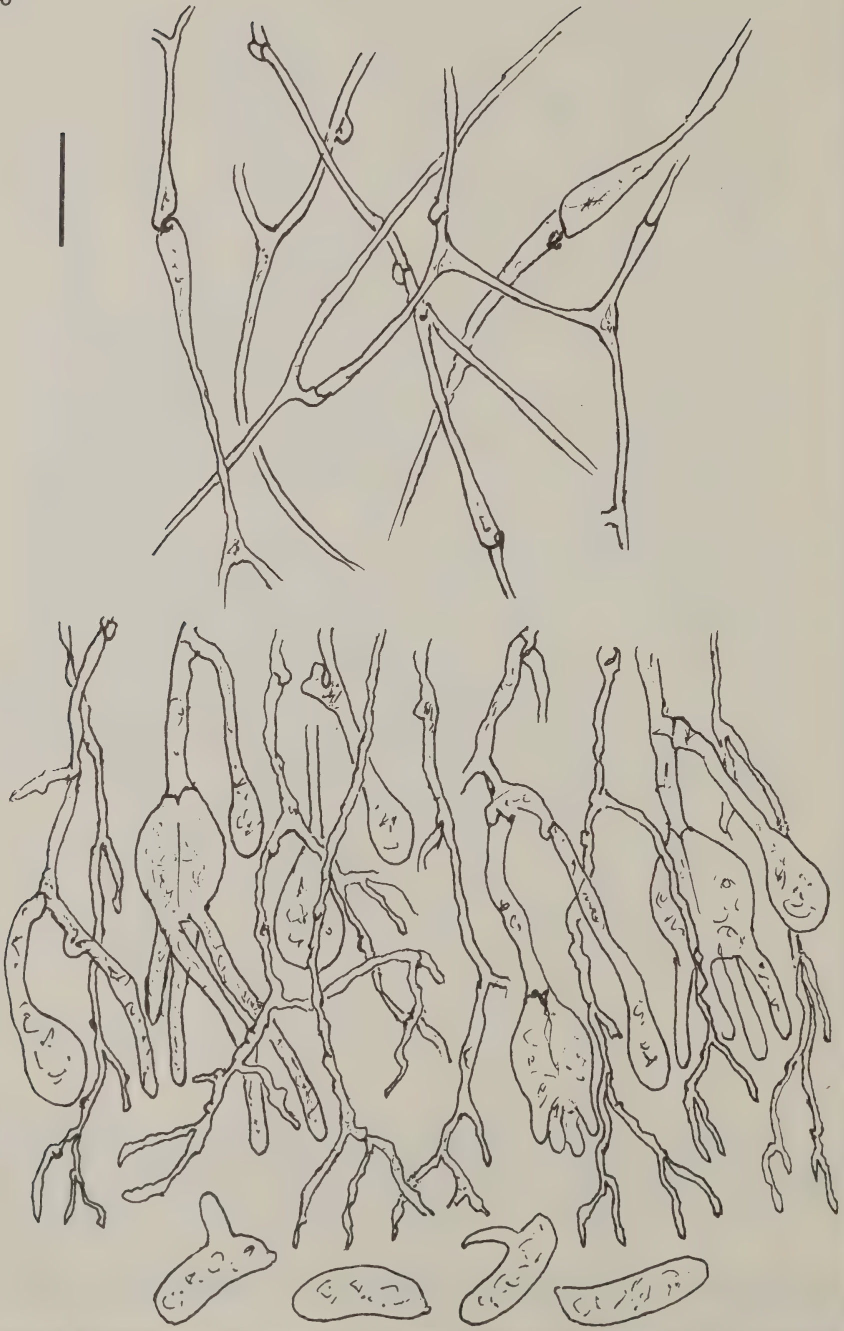

Fig. 8. *Myxarium nucleatum* f. *nucleatum*. Section of fruitbody (K. Hauerslev 6068). Bar = 10 µm.

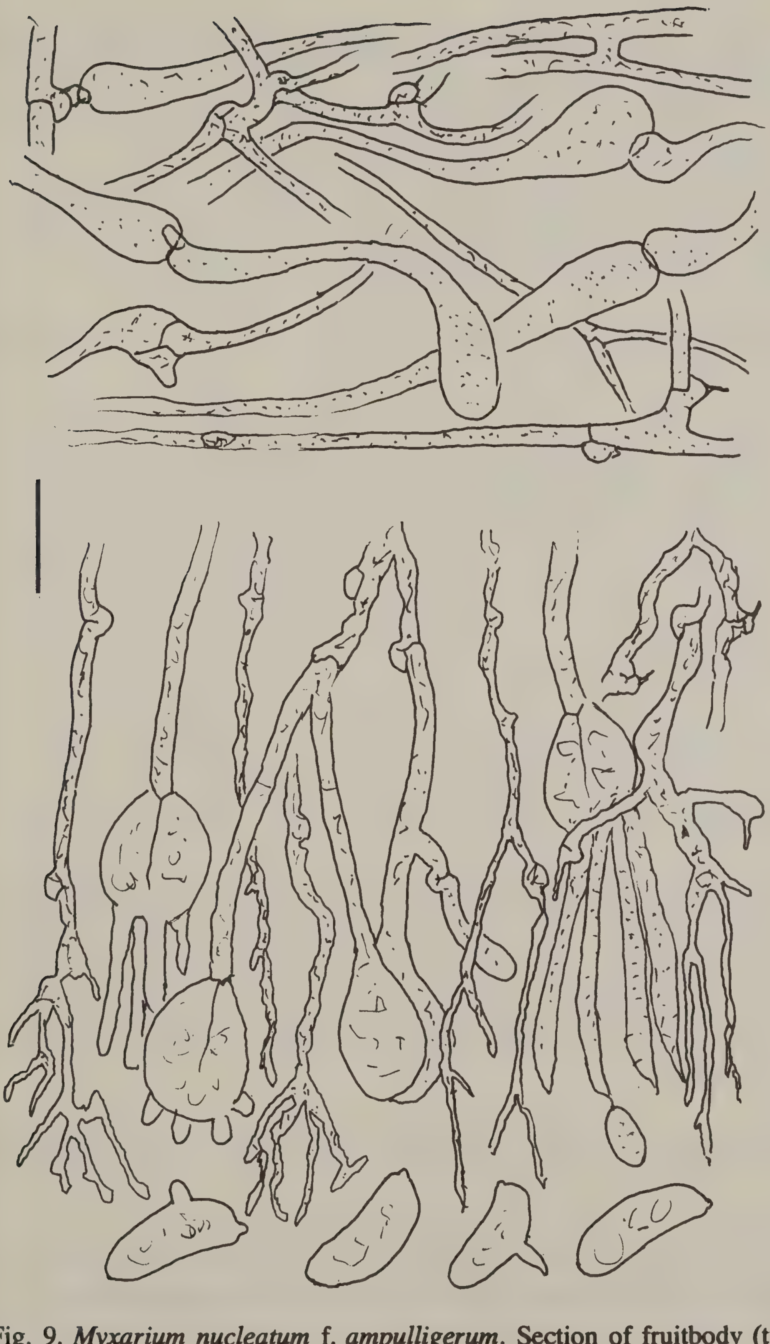

Fig. 9. *Myxarium nucleatum* f. *ampulligerum*. Section of fruitbody (type). Bar = 10 µm.

Other material: Czechoslovakia: Velký Ròckov, VIII. 1934, on *Abies alba*, A. Pilát. Denmark: Korsør Skov, 24.XII. 1959, on *Diatrype disciformis* on *Fagus*, K. Hauerslev 1602; Korsør Skov, 24.XII.1959, on *Fagus*, K. Hauerslev 1686; Korsør Skov, 22.IV.1957, on *Fagus*, K. Hauerslev 2208.
Notes: When asking for type material in PC, three specimens were received, all authentic and named *Sebacina mesomorpha*. Two of these exactly have the spore–size given by Bourdot & Galzin, while the third (Bourd. 13956/Galz. 14319) is a form of *Bourdotia galzinii* (Hauerslev in press).

*Myxarium nucleatum* Wallr. forma *nucleatum*, Fig. 8.
Fl. crypt. Germ. 2: 260, 1833

Fructification whitish–gelatinous, somewhat lilaceous, often with calcareous cores, drying to a yellowish to brownish film. Hyphae c. 1 μm broad, some lower hyphae ampullately swollen, up to 3 μm broad, with clamp connections. Hyphidia branched, 1–2 μm broad. Basidia myxarioid, apical part 10–14 × 7–10 μm. Spores cylindric, 9–14(–15) × 4–5(–5.5) μm, forming secondary spores.
Material: Denmark, Korsør, Taarnborg Park, 24.VII.1966, on deciduous wood, K. Hauerslev 6068.
Notes: Common in Denmark.

*Myxarium nucleatum* forma *ampulligerum* Hauerslev f. nov. Fig. 9.
*Myxarium nucleatum* affine sed hyphis usque ad 6(–7) μm diam.
Holotype: Denmark, Lolland, Torrig Skov, 20.X.1986, on pyrenomycete in holes in the bark of deciduous wood, K. Hauerslev 6836.

Pale yellow as some *Dacrymyces* spp., 0.5–1 mm, semi–globular to small cylindric, may spread a little over the bark, drying brownish yellow. A white "nucleus" is present in some fruitbodies. Hyphae 1.5–2 μm with clamp connections, lower hyphae ampullately swollen at septae to 4–6(–7) μm. Hyphidia more or less branched. The head of the basidia 9–10 x 10–14 μm, the stalk 15–20 μm. 2–4 sterigmata. Spores ellipsoid to cylindric, 10–14 x 4–5 μm. Forming secondary spores.

*Myxarium podlachicum* (Bres.) Raitviir in Parmasto, Fig. 10.
Zhivaya priroda Dalnego Vostoka 1971: 113

Fruitbody resupinate, gelatinous, drying yellowish–brown. Hyphae and hyphidia ca. 1.5–2 μm broad. Basidia myxarioid, apical part about 8–10 × 7.5–9.5 μm. Spores cylindric to ellipsoid, 7.5–9.5 x 3–4 μm, forming secondary spores.

Material: Denmark, Holte, 30.X.1977, K. Hauerslev 6057.

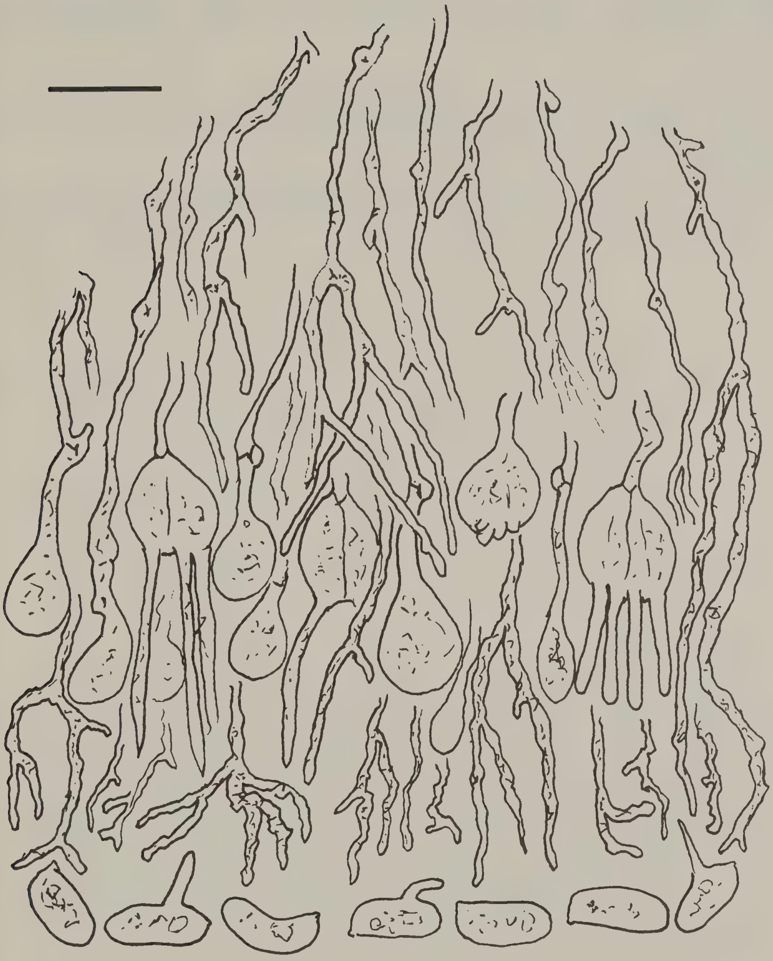

Fig. 10. *Myxarium podlachicum*. Section of fruitbody (K. Hauerslev 6057). Bar = 10 µm.

Notes: Rather common in Denmark. Mostly collected on decayed wood of *Fagus*, more rarely on *Corylus* and *Phellinus*.

**Myxarium sphaerosporum** (Bourd. & Galz.) Reid, Persoonia 7: 297. Fig. 11.

Basionym: *Sebacina sphaerospora* Bourd. & Galz., Bull. Soc. mycol. Fr. 39: 263, 1924.

Fructification thin, gelatinous. Hyphae indistinct, 0.5–3 µm, with clamp connections. Basidia myxarioid, apical part 7–10 x 5.5–7.5 µm. Spores globose to subglobose, 4.5–6 µm.
Syntype: France, sur Aune, September 1914, Bourd. 14094/Galz. 16069 (K).
Other material: Denmark: Vemmetofte Skov, 23.9.1977, K. Hauerslev 5577.

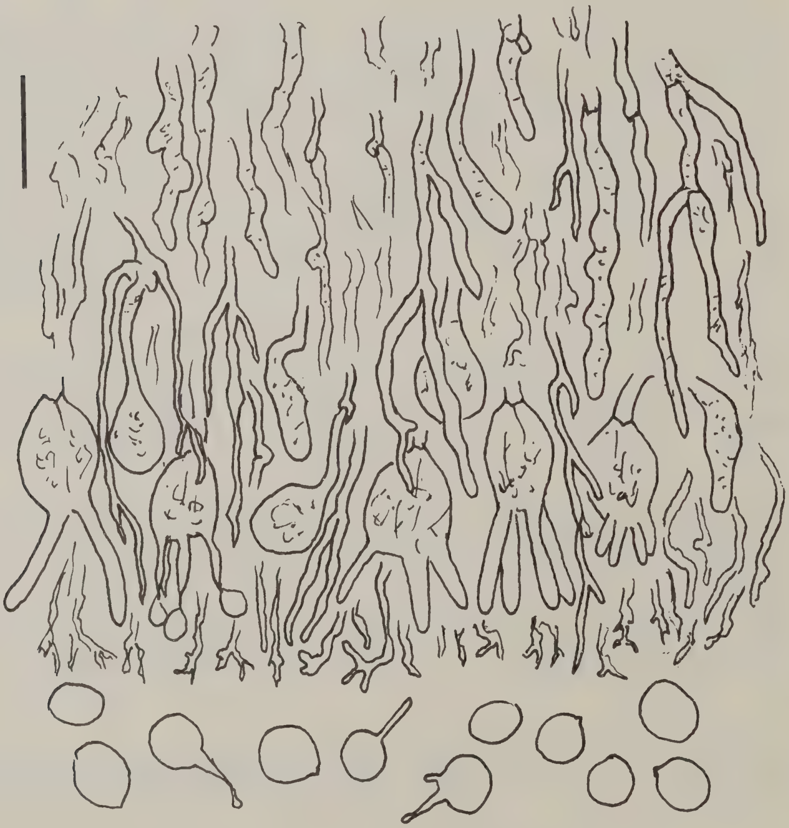

Fig. 11. *Myxarium sphaerosporum*. Section of fruitbody (syntype). Bar = 10 µm.

***Myxarium subgilvum*** **Hauerslev n.sp.** Fig. 12.
*Myxario gilvo* affine sed sporis 6–9 × 4–6 µm.
Holotype: Denmark, Korsør Skov, 11.IX.1965, on pyrenomycete on bark of *Betula* or *Alnus*, K. Hauerslev 3045.

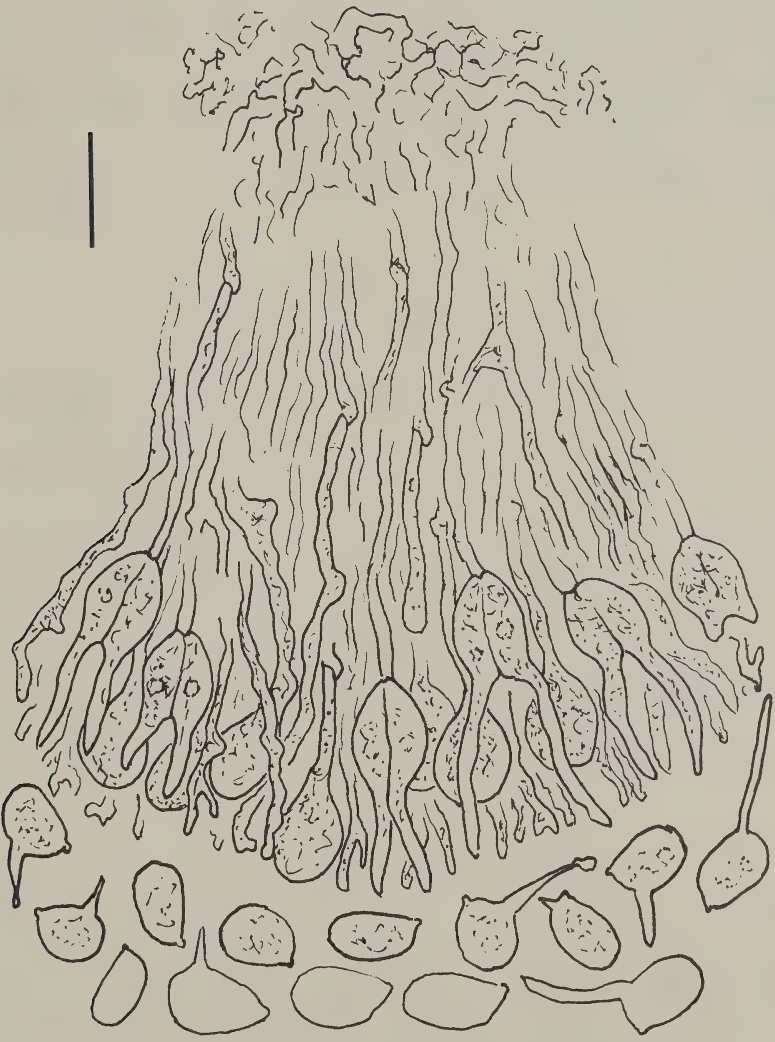

Fig. 12. *Myxarium subgilvum*. Section of fruitbody (K. Hauerslev 5828). Bar = 10 µm.

Fructification gelatinous, drying to a brownish yellow–hyaline vernicose film, partly reticulate. Hyphae indistinct, about 2 µm broad, with clamp connections. Hyphidia 1.5–2 µm broad, simple to branched. Basidia myxarioid, the apical part 7–10 × 6–8 µm, 2-celled by longitudinal division. Sterigmata up to 16 µm long. Spores subglobose to ellipsoid, 6–9 × 4–6 µm with a small apiculus, forming secondary spores.

Other material: Denmark: Aabenraa, Jørgensgaard Skov, 11.VIII.1966, on wood, K. Hauerslev 2680; Næsbyholm Storskov, 6.IX.1970, on wood, K. Hauerslev 3642; Ørholm, 2.X. 1971, on wood, K. Hauerslev 4195; Tved Plantage, 9.X.1971, on wood, K. Hauerslev 4204; Ørholm, 14.X.1979, on *Salix* or *Ulmus*, K. Hauerslev 5828.

Notes: *Myxarium subgilvum* differs mainly from *M. gilvum* by the smaller spores.

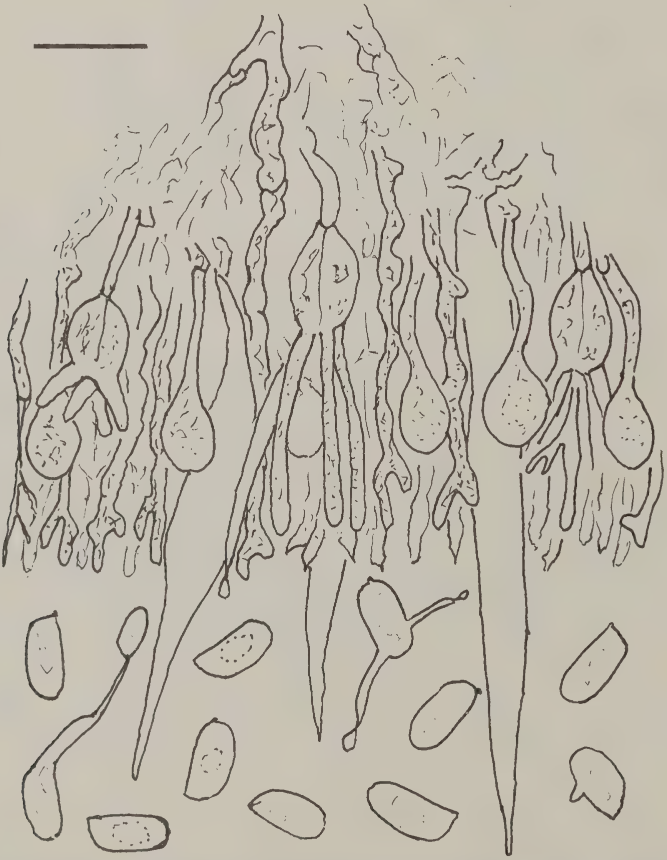

Fig. 13. *Myxarium subhyalinum*. Section of fruitbody (K. Hauerslev 7247). Bar = 10 µm.

*Myxarium subhyalinum* (Pears.) Reid, Fig. 13.
Trans. Br. mycol. Soc. 55: 426, 1970.
Basionym: *Sebacina subhyalina* Pears., Trans. Brit. mycol. Soc. 13: 71, 1928.

Fruitbody a hyaline greyish to lilaceous membrane, sometimes with calcareous nodules, drying to a vernicose film. Hyphae indistinct. Hyphidia simple or branched. Leptocystidia subulate, 30–60 × 4–7 µm, emerging. Basidia myxarioid, the apical part 7–10 x 6–8 µm, becoming longitudinally divided into 4 cells. Spores ellipsoid to cylindric, 6.5–8 × 3–4 µm, forming secondary spores.
Material: Denmark, Hareskoven, 14.XI.1991, K. Hauerslev 7247.
Notes: *Myxarium subhyalinum* is rather common in Denmark, collected on *Betula*, *Fagus*, *Fraxinus*, *Tilia*, *Ulmus* and *Diatrype stigma* but most often on unidentified wood.

*Myxarium varium* Hauerslev n.sp. Fig. 14.
Fructificatio resupinata, hyalina, brunneo–cremea, usque ad 150 µm crassa, laevis vel parce tuberculosa. Hyphae tenuiter tunicatae, indistinctae, 1–6 µm latae, noduloso–septatae. Hyphidia simplicia vel ramosa, 0.5–2 µm diam. Basidia myxarioidea, usque ad 25 µm longa, capitibus 7–9 × 6–8 µm, 4 sterigmatibus usque ad 20 µm longis. Sporae subovatae vel suballantoideae, hyalinae, tunicis tenuibus, laevibus, 6.5–8.5(–9) × 3–5 µm, apiculatae, per repetitionem germinantes.
Holotype: Denmark, Vemmetofte Skov, 23.IX.1977, K. Hauerslev 6097.

Fruitbody effused, hyaline, up to 150 µm thick, smooth or little verrucose, brownish–yellow. Hyphae thin–walled, 1–6 µm broad, irregular and somewhat indistinct, with clamp connections. Hyphidia simple or branched, 0.5–2 µm broad. Basidia of the myxarioid type, up to 25 µm long, the "head" 7–9 × 6–8 µm, becoming 4–celled by longitudinal division. Sterigmata up to 20 µm long. Spores subovoid to ellipsoid to suballantoid, thin–walled, smooth, 6.5–8.5(–9) × 3–5 µm, apiculate, forming secondary spores.
Notes: Hyphae of this species are variable in form and thickness. The broad ones are unequally dispersed in the fruitbody.

*Myxarium vernicosum* Hauerslev n.sp. Fig. 15.
Fructificatio resupinata, in sectione 50–80 µm crassa, hyalina, siccitate vernicosa vel membranacea isabellina. Hyphae hyalinae, tenuiter tunicatae, indistinctae, conglutinatae, 1–2.5 µm latae. Hyphidia simplicia vel ramosa, 1–3 µm diam., numerosa. Leptocystidia ventricosa vel cylindracea, intus materia hyalina, usque ad 40 × 15 µm. Basidia myxarioidea, usque ad 25 µm longa, capitibus 8–10 × 6–8 µm, 2–4 sterigmatibus usque ad 15 µm longis. Sporae ellipsoideae vel subcylindraceae, hyalinae, tunicis tenuibus, laevibus, 7–8(–9) × 3–4.5 µm, apiculatae, per repetitionem germinantes.
Holotype: Denmark, Falster, Korselitse Skov, 16.IX.1980, K. Hauerslev 6089.

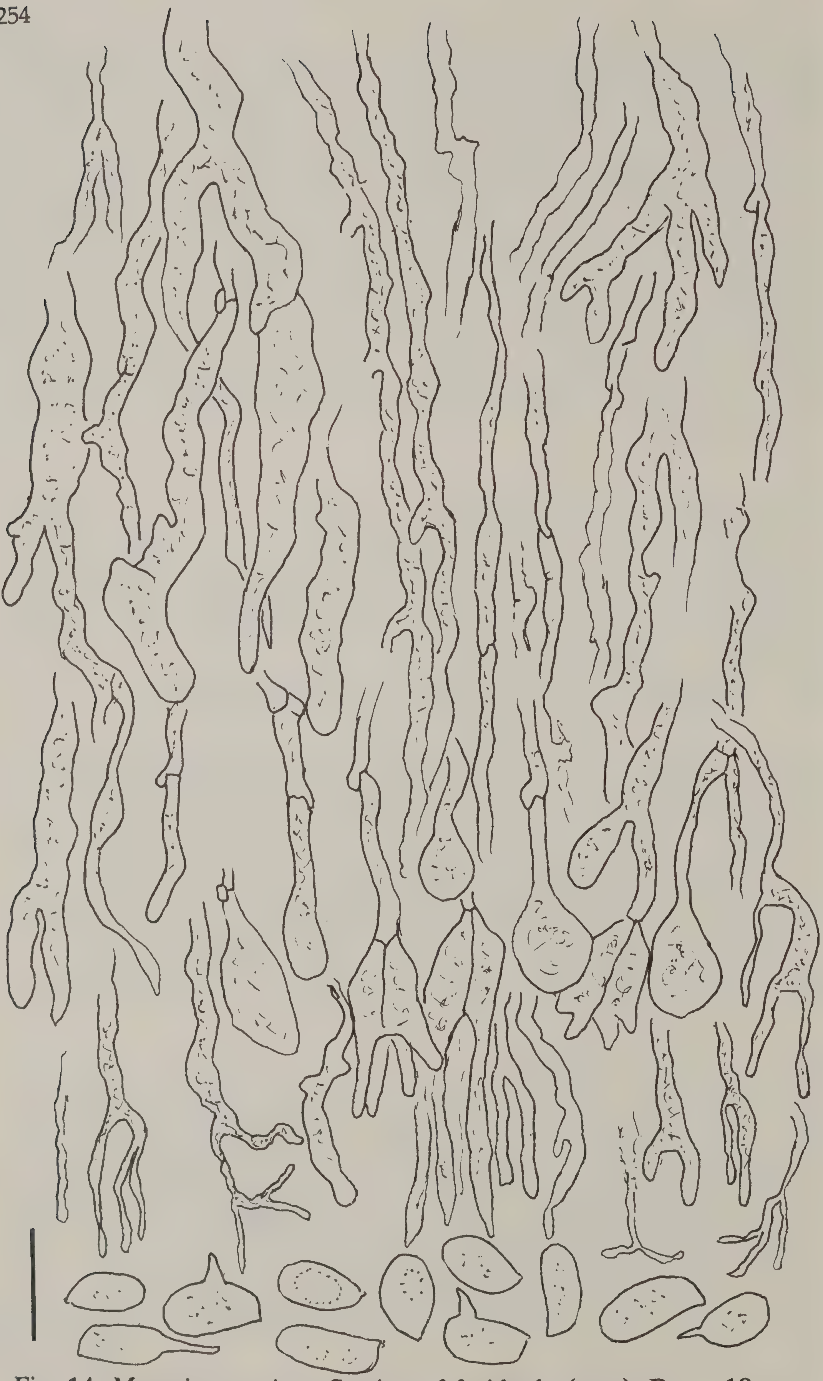

Fig. 14. *Myxarium varium*. Section of fruitbody (type). Bar = 10 µm.

Fruitbody up to 80 µm thick, hyaline, drying vernicose or to a thin yellowish loosely attached membrane. Hyphae thin–walled, not easily distinguished, closely agglutinated, irregular, 1–2.5 µm wide, nodulose septate. Hyphidia thin–walled, simple or branched, 1–3 µm wide. Leptocystidia ventricose to cylindric, contents hyaline, up to 40 x 15 µm. Basidia of the myxarioid type, up to 25 µm long, the "head" 8–10 × 6–8 µm, with 2–4 sterigmata up to 15 µm long. Spores ellipsoid to subcylindric, thin–walled, smooth, 7–8(–9) × 3–4.5 µm, apiculate, forming secondary spores.

Other material: Denmark, Vemmetofte Skov, 23.IX.1977, on wood, K. Hauerslev 6428; Korsør Skov, 2.XI.1983, on wood, K. Hauerslev 6282; Sorgenfri, 12.VI.1988, on wood and pyrenomycete, K. Hauerslev 6921; Suserup Skov, 14.XI.1991, on wood, J. Heilmann–Clausen 91–651.

Notes: This species is characteristic with its leptocystidia which are unequally dispersed in the fruitbody.

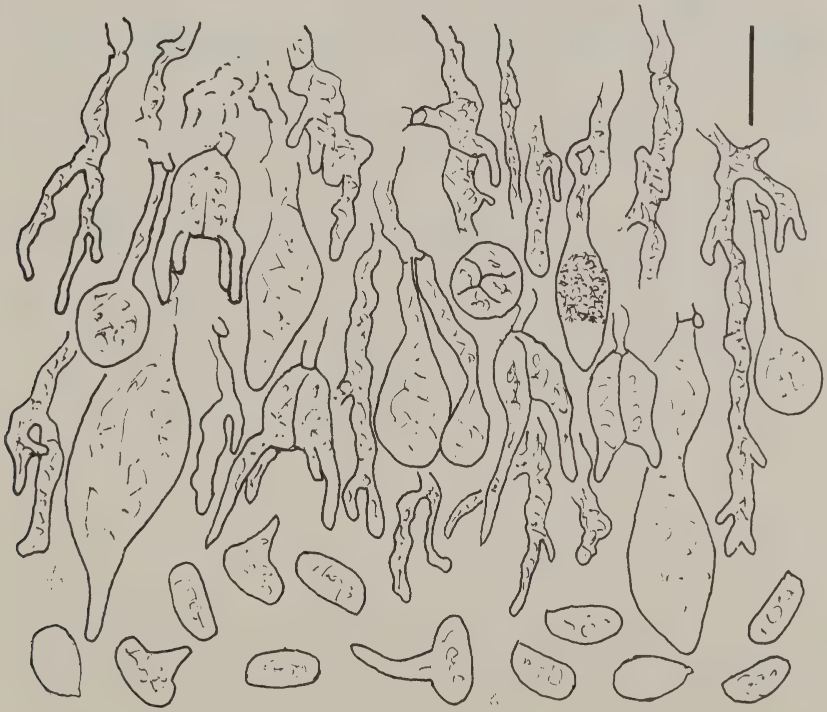

Fig. 15. *Myxarium vernicosum*. Section of fruitbody (type). Bar = 10 µm.

## Acknowledgements

F. Oberwinkler (Tübingen) and H. Knudsen are warmly thanked for critically reading the manuscript, Tyge Christensen for checking the Latin diagnoses and H. F. Gøtzsche for technical help. The curators of C, K and PC are thanked for providing material.

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# DESCRIPTIONS OF NEW TAXA OF ERYSIPHACEAE FROM ARGENTINA

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## SUMMARY

One variety and four species of Erysiphales are described as new: *Erysiphe ulmariae* var. *acaenae* var. nov., *Microsphaera Oehrensii* sp. nov., *M. ovidiae* sp. nov., *M. ribicola* sp. nov. and *Oidium mutisiae* sp. nov.

## INTRODUCTION

The Nahuel Huapi National Park is situated in the South-West of Argentina and has a vegetation that is characterized by typical Andean patagonic forests. In this area with a rich flora, we studied the powdery mildews (Erysiphaceae) that infect autochtonous hosts and collected one new variety and four undescribed species. We propose the following new names: *Erysiphe ulmariae* var. *acaenae* var. nov on *Acaena pinnatifida* Ruiz et Pavon, *Microsphaera Oehrensii* sp. nov. on *Maytenus magellanica* (Lam.) Hook f., *M. ovidiae* sp. nov. on *Ovidia andina* (Poepp. et Endl.) Meissn., *M. ribicola* sp. nov. on *Ribes magellanicum* Poiret and *Oidium mutisiae* sp. nov. on *Mutisia spinosa* Ruiz et Pavon.

## TAXONOMIC PART

**Erysiphe ulmariae** Desm. (1846) **var. acaenae** var. nov.
(Fig.1, A-C )

A typo differt appendicibus non septatis. Asci con 5-6 sporis, ascosporae longioris.
Habitat in foliis vivis *Acaena pinnatifida* Ruiz et Pavon.

*Colonies*: Mycelium superficial, amphigenous, mostly epiphyllous, effuse, persistent on living leaves and stems. Vegetative hyphae 4 to 5 mµ wide.

*Teleomorph*: Cleistothecia somewhat flattened in side view, gregarious, (80-) 100-148 µm diam. Peridium thin, asci and ascospores visible inside the ascocarp. Peridium cells 5-7 (-20) µm diam.Appendages: more than 30, in the upper half, sometimes equatorially arising, lenght variable, more than 4-5 times as long as the cleistothecial diameter, mycelioid, simple, smooth, some oriented to one side of the cleistothecia. Wider at the very base, 4 µm.
Asci: 9 to 12; 70-90 x 30-40 µm, elongated, stalked, 5- to 6-spored.
Ascospores: ellipsoid-ovoid to subglobose, (18-) 20-28 x 14-18 µm.

*Anamorph*: Conidiophores not observed.
Conidia: cylindric, 28-36 x 12-16 µm.
Germination: not observed.
Appressoria: multilobed, abundant, frequently on the both oposite sides of the hyphae.

*Etymology*: *acaenae*, refers to the host plant genus, the only substrate on which this variety has been found.

*Host*: *Acaena pinnatifida* Ruiz et Pavon (Rosaceae). Native perennial herb, widely distributed in the Andean patagonic area.

*Studied material*: ARGENTINA, *Provincia Río Negro: depto. Bariloche*, Cerro Otto, in *Nothofagus pumilio* woods, leg. Havrylenko, IV-1991.
Holotypus: LPS 45135, *Isotypi*: HAL, MH 21, BCRU 326.
*Comments: Erysiphe ulmariae* was described on four species of *Filipendula (Rosaceae)* in all Europe, Asia (Kazakhstan, Siberia, far East of Russia and Japan (Braun, 1987). This variety differs from the former species by 5-6- spored asci, larger ascospores and septate appendages.

**Microsphaera Oehrensii** sp. nov.
(fig. 1, D-G)

Mycelium amphigenum, persistens, effusum vel aliquando pelliculas efformans. Cleistothecia disseminata et sparsa, 80-96 µm diametro. Cellulae peridii irregulariter angulatae, ca. 17-20 µm diametro. Appendices 8 vel 12, diametro cleistothecii 4 prolongiores, 1 septatae, hyalinae, verruculosae, parte basilari aliquando lutescens. Apice dichotome ramosae, rami ultimi ramificatione laxa. Asci 4-5, breviter pedicellati vel sessiles, ca. 50-60 x 30-44 µm. Ascosporae 3-5, ellipsoideae (20-) 22-24 x 10-12 µm. In statu imperfecto: *Oidium robustum* U. Braun et Oehrens B. (1986).
Habitat in foliis vivis *Maytenus magellanica* ( Lam.) Hook.

*Colonies*: Mycelium amphigenous, effuse or in patches, persistent, white, on living leaves. Hyphae ca. 4-8 µm wide.

*Teleomorph*: Cleistothecia scattered and scarce, 80-96 µm diameter, peridium thin, cells irregularly polygonal, 17-20 µm diameter.
Appendages: subequatorially arising, 8 to 12, flexuous, undulate, geniculate, rough-walled, yellowish at the base, 4 times as long as cleistothecial diameter. One septum from the middle downward. Apex simple to one time dichotomously branched, branching loose.
Asci: 4 to 5, sessile or shortly stalked, ca. 50-60 x 30-44 µm, 3- to 5- spored.
Ascospores: ellipsoid, (20-) 22-24 x 10-12 µm.

*Anamorph*: *Oidium robustum* U. Braun & Oehrens B. (1986).

*Etymology*: *Oehrensii*, from Oehrens, in memoriam to the late professor Edgar Oehrens, a mycologist from Chile, South America.

*Host*: *Maytenus magellanica* (Lam.) Hook. f. (Celastraceae). Evergreen native shrub with hairless and leathery leaves.

*Studied material*: ARGENTINA, *Provincia Río Negro: depto. Bariloche*, Llao Llao, trail to Lago Moreno, leg. Havrylenko, 21-IV-1991.
*Holotypus*: LPS 45138, *Isotypi*: HAL, MH 26, BCRU 327

*Comments*: This species has an unique combination of characters quite different from other *Microsphaera* species. The anamorph *Oidium robustum* was named and recorded for Argentina on *Maytenus boaria* Mol. (Celastraceae) by Braun & Oehrens (1986). We recorded the anamorph on *Maytenus boaria* and *M. magellanica*, but the perfect state is only known on the latter host.

**Microsphaera ovidiae** sp. nov.
(Fig. 2, A-E )

Mycelium amphigenum, tenue, evanescens. Cleistothecia gregaria vel disseminata (88-) 99-126 µm diametro. Cellulis parietalibus exterioribus 10-20 µm diametro. Appendices 11-12, diametro cleistothecii 2 prolongiores, hyalinae, uniseptatae, parti basilari aliquando brunneae et laeves vel verruculosae. Apice 4-5 dichotome ramosae, rami primarii saepe majores, ramis ultimis recurvatis sed rami distales saepe extensi. Asci 3-5 in quoque cleistothecio, breviter pedicellati (48-) 50-60 x 43-42 µm. Ascosporae 4-6, fere ellipsoideae vel ovoideae 20-24 x 10-12 µm.
Habitat in foliis vivis *Ovidia andina* (Poepp. et Endl.) Meissn.

*Colonies*: Mycelium amphigenous, thin, evanescent. Hyphae branched,ca. 6 µm diameter, on living leaves.

*Teleomorph*: cleistothecia scattered to gregarious (88-) 99-126 µm diam. Peridium with polygonal cells, 10-20 µm diam. Appendages: equatorial, 11 to 16, stiff to curved, 2 times as long as the cleistothecial diameter. Hyaline to slighty yellow and rough at the base. Walls thick at the base and thinner toward the apex. One septate, 10 µm wide at the base.

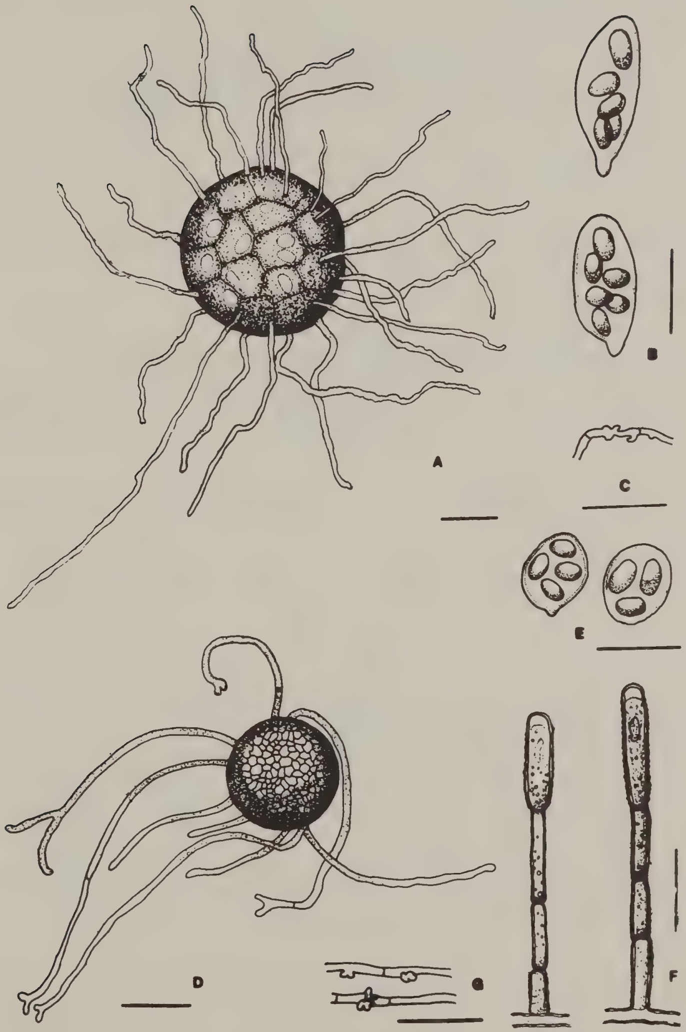

Figure 1. A–C: *Erysiphe ulmariae* var. *acaenae* var. nov.; A: Cleistothecium; B: Asci; C: Hyphae and appressoria. D–G: *Microsphaera Oehrensii* sp. nov.; D: Cleistothecium; E: Asci; F: Anamorph *Oidium robustum* U. Braun & Oehrens B.; G: Hyphae and appressoria.
The bars represent in all cases 50 µm.

Apex 4 to 5 times dichotomously branched; primary branches some times elongated, tips recurved, but frequently the distal ones extended.
Asci: 3 to 5 per ascocarp, shortly stalked, (48-) 50-60 x 34-42 µm, with 4 to 6 spores, mostly 5 spored.
Ascospores: ellipsoid-ovoid, 20-24 x 10-12 µm.

*Anamorph*: Conidiophores not observed.
Conidia: cylindric; 28-32 x 14-18 µm, measured in dry stage.
Germination: observed on conidia, germinating spontaneously on leaves, forming a simple, subapical tube.
Appressoria: lobed.

*Etymology*: *ovidiae*, refers to host plant genus.

*Host*: *Ovidia andina* (Poepp. et Endl.) Meissn. (Thymeleaceae), native, perennial shrub.

*Studied material*: ARGENTINA, *Provincia Río Negro: depto. Bariloche*, lago Frías, trail to Paso de las Nubes, leg. Havrylenko, III-1992.
*Holotypus:* LPS 45137, *Isotypi*: HAL, MH 100, BCRU 328

*Comments*: This species was only found at the type locality. It is not frequent.
This is the first record of a powdery mildew on *Ovidia andina* from Argentina. A conidial state on *Ovidia pillo pillo* is known from Chile (Braun, 1987).The latter hostis synonymous with *Ovidia andina* (Correa, 1988). The conidia seems to be smaller (12-26 µm) than those in *Microsphaera ovidiae*. This species closely resembles to *Microsphaera miurae* (cf. Braun 1987, pag. 476), but differs by larger cleistothecia, stalked asci, larger and more numerous appendages and smaller ascospores.

## **Microsphaera ribicola** sp. nov.
(Fig. 3, A-D)

Mycelium epiphyllum, effusum, tenue vel evanescens. Cleistothecia disseminata et sparsa, (60-) 70-120 µm diametro. Cellulis peridii irregulariter angulatis. Appendices 12-16. Appendicibus longis diametrum cleistothecis aequantibus, uniseptatae. Apices 5-6 dichotome ramosae, ramis ultimis recurvatis. Asci 4-8 in quoque cleistothecio,

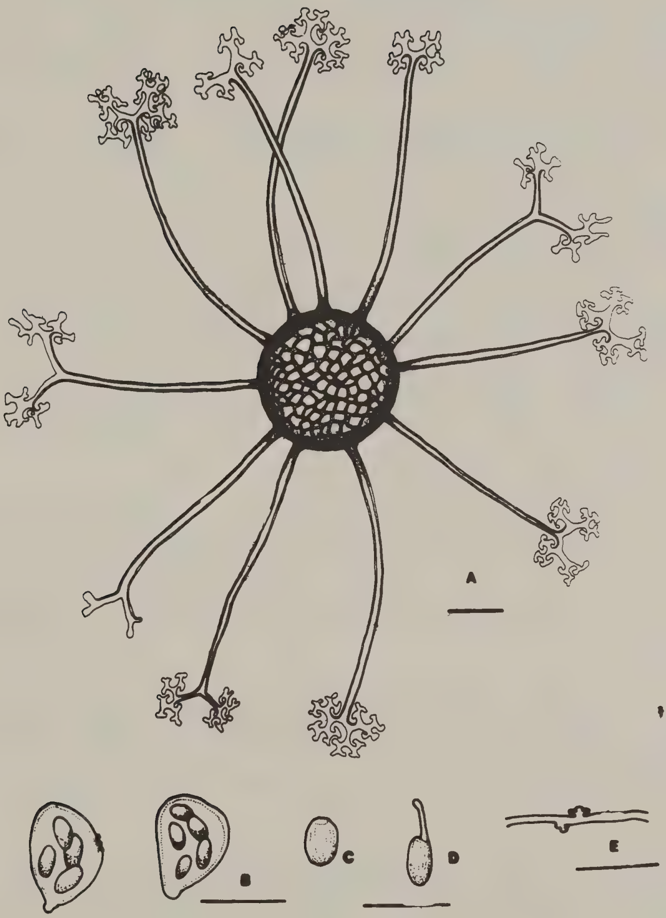

Figure 2. A–E: *Microsphaera ovidiae* sp. nov.; A: Cleistothecium; B: Asci; C: Conidium; D: Germinated conidium; E: Hyphae and appressoria.
The bars represent in all cases 50 µm.

breviter pedicellati vel sessiles. Ascosporae 5–6, ellipsoideae vel ovoideae, 20–28 x 10–12 µm.
Habitat in foliis vivis *Ribes magellanicum* Poiret.

*Colonies*: Mycelium superficial, hyaline, epiphyllous, forming white effuse or thin patches on living leaves. Vegetative hyphae 4 µm wide.

*Teleomorph:* Cleistothecia somewhat flattened in side view, (60-) 70- 120 µm diam. Scattered and scarce. Peridium cells irregularly polygonal.
Appendages: 12 to 14, as long as the cleistothecial diameter, equatorially arising, thick-walled and with one septum near the base.
Apex 5 to 6 times dichotomously branched. Tips recurved.

Asci: 4 to 8, sessile to shortly stalked, broadly ellipsoid, 44-45 x 32-38 µm, 5 to 6 spored.
Ascospores: ellipsoid-ovoid, 18-20 x 9-10 (-12) µm.

*Anamorph*: Conidiophores Pseudoidium type, short, curved.
Foot cells: cylindric, slighty curved, 18-24 x 6-10 µm, followed by one shorter cell.
Conidia: formed singly, cylindric, 28-30 x 10-12 µm.
Germination: Polygoni type, seen in naturally germinated conidia on leaves.
Appressoria: nipple shaped to slighty lobed.

*Etymology: ribicola*, refers to host plant genus, the only substrate on which this species has been found.

*Host: Ribes magellanicum* Poiret. (Grossulariaceae). Native deciduous shrub.

*Studied material* : ARGENTINA. *Provincia Río Negro: depto. Bariloche,* trail to Cerro Catedral, near Las Latas bridge, leg. Havrylenko,V-1990.
*Holotypus*: LPS 45136, *Isotypi*: HAL, MH 12, BCRU 329

*Comments*: This species was only found at the cited locality and was very scarce. It is suggested that there is a competitive relation with *Phyllactinia antarctica* Speg. which colonized the lover surface of the same host leaves and allowed the infection by *Microsphaera ribicola* on the upper surface. It was noted that *Phyllactinia antarctica* is mostly hypophyllous, but could also be amphigenous.

### Oidium mutisiae sp. nov.
(Fig. 3, E-H)

Mycelium amphigenum, persistens, pelliculas efformans, album vel cineraceum. Hyphae septatae, 5-6 µm latae, crasse tunicatae et asperae. Cellulae basi cylindricae, dilatatae supra, 50-110 (-160) x 10-12 µm, sequentes 2 brevis cellulae.

Conidia doliiformia, 30-42 x 14-20 µm, tunicata aspera.
Appressoria mammiliformia vel unciformia.
Habitat in foliis vivis *Mutisia spinosa* Ruiz et Pavon et *Mutisia decurrens* Cavanilles.

*Colonies*: Mycelium amphigenous but mostly on the abaxial surface of leaves and main veins, persistent, forming white-grey patches. Vegetative hyphae septate, branched, with thick and rough walls, 5-6 µm diam.

*Anamorph*: Conidiophores Euoidium type.
Foot cells: cylindric, slighty increasing from base to top, 50-110(-160) x 10-12 µm, followed by 2 much shorter cells.
Conidia: seem to be formed in chains, doliiform, 30-42 x 14-20 µm, with rough walls.
Germination: not seen.
Appressoria: nipple-shaped.
Fibrosine bodies: absent.

*Etymology: mutisiae,* refers to host plant genus.

*Hosts*: *Mutisia spinosa* Ruiz et Pavón and *Mutisia decurrens* Cavanilles (Compositae). Native perennial vines, widely distributed in the Andean patagonic area.

*Studied material*: ARGENTINA, *Provincia Río Negro*: *depto. Bariloche,* lago Moreno, on *Mutisia spinosa, leg.* Havrylenko,V-1991; on *Mutisia decurrens,* leg. Havrylenko, V-1991.
*Holotypus*: LPS 45139 (on *Mutisia spinosa), Isotypi*: HAL, MH 31,BCRU 330.

*Comments:* The description of this species was prepared on the basis of the specimen on *Mutisia spinosa.*This species is very similar to the *Oidium* observed on *Mutisia decurrens,* but differ from the former in the following characteristics: Hyphae wide, 6-8 µm, branched at right angles. The colonies are more abundant at the upper surface of leaves. Foot cells are very rough and germinating conidia with simple apical tube were observed. Appressoria show an unusual hooked form.

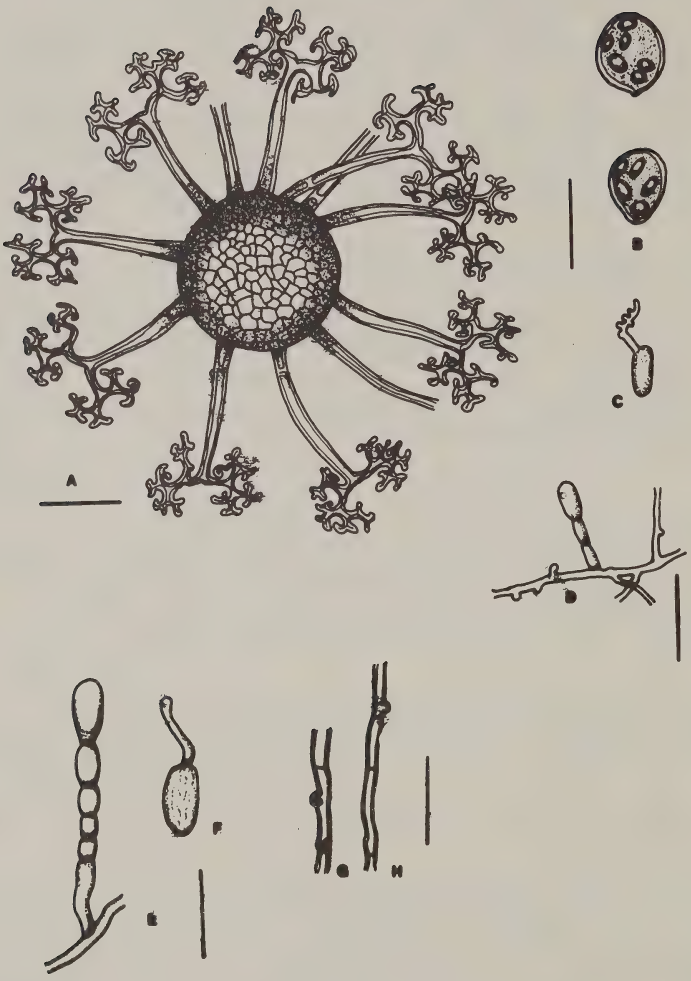

Figure 3. A–D: *Microsphaera ribicola* sp. nov.; A: Cleistothecium; B: Asci; C: Germinated conidium; D: Conidiophore. E–H: *Oidium mutisiae* sp. nov.; E: Conidiophore; F: Germinated conidium; C–H: Hyphae with appressoria. The bars represent in all cases 50 µm.

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# ILLINOIS SPECIES OF VOLVARIELLA (BASIDIOMYCETES, AGARICALES, PLUTEACEAE)

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## ABSTRACT

In his monograph of *Volvariella* in North America, Shaffer reported only two species from Illinois, *V. bombycina* (Schaeff.: Fr.) Singer and *V. speciosa* (Fr.) Singer. Known only from Cook, DuPage, Henry, and Rock Island Counties, it appeared that *Volvariella* was rare in Illinois and restricted to the northern fifth of the state. Studies of both additional herbarium material and collections made by us from other parts of Illinois support a broader distribution pattern and greater diversity of species. Although populations of *Volvariella speciosa* appear restricted to the northern part of Illinois, *V. bombycina* ranges throughout the state. New records for Illinois include *V. hypopithys* (Fr.) Moser apud Gams, *V. pusilla* (Pers.: Fr.) Singer, *V. taylori* (Berk.) Singer, and *V. volvacea* (Bull.: Fr.) Singer. Lack of previous reports of these taxa in the state may be due to the smaller size and more ephemeral nature of their basidiomata. In Illinois, species of *Volvariella* fruit from late June to early October--the warm, often humid, summer to early fall weather period. Recorded frequency and distribution of species appear related to substrate availability (much of the middle part of the state is high-grade prairie farm land) and the presence of a collector during the period of fruiting.

## INTRODUCTION

Over the past several years, each of us has collected fungi at different localities in Illinois and sporadically encountered a number of *Volvariella* species. Of particular interest were the smaller, more ephemeral taxa which are frequently overlooked. Previous reports of *Volvariella* in Illinois were made by French (1907), Moffat (1909), McDougall (1917), Graham (1944), Eifert (1950), and Shaffer (1957). A survey of the literature and our own data revealed very few recent collections of the genus from Illinois. Therefore, we decided to initiate a project to better understand the species of *Volvariella* which occur in Illinois and their geographical ranges within the state. Although basidiomata of some *Volvariella* species are infrequently encountered (Orton 1986), this collaborative project resulted in an increase in the number of *Volvariella* taxa known from Illinois from two to six and extended the geographical ranges of taxa previously reported from the state.

## MATERIALS AND METHODS

Standard techniques for the collection, preservation and description of agarics have been followed. Color terms were taken from Kornerup and Wanscher (1978). Micromorphological features were studied and measurements were made in material revived in 95% ethanol and water, then sectioned, and mounted in 3% KOH with or without phloxine stain. Specimens were deposited in the herbaria at Bradley University (BU), Eastern Illinois University (EIU), and Southern Illinois University at Carbondale (SIU). In addition to collections at BU, EIU, and SIU, specimens in the herbaria at the Field Museum of Natural History, Chicago (F) and the University of Michigan (MICH) were examined and annotated.

The monographic treatments of *Volvariella* prepared by Shaffer (1957, 1962) and Orton (1986) preclude the necessity for lengthy descriptions and comprehensive lists of nomenclature in this paper. The reader should consult these publications for details. Where observed by us, variations in descriptive data for the taxa are noted and discussed. Distributional data from the works of French (1907), Moffat (1909), McDougall (1917), Graham (1944), Eifert (1950), and Shaffer (1957) are accepted without question only if voucher collections were found.

## RESULTS AND DISCUSSION

***Volvariella bombycina*** var. ***bombycina*** (Schaeff.: Fr.) Singer, Lilloa 22: 401. 1951. Figs. 1-3 and 7.

Descriptive data: This taxon is adequately described in Shaffer (1957) and Orton (1986).

Specimens examined: Coles Co.: Fox Ridge State Park, 14.ix.1978, W. McKnight s.n. (EIU). Cook Co.: Evanston, 10.ix.1938, Edgecomb s.n. (F 1202736) and Evanston, 29.vii.1939, Edgecomb s.n. (F 1224938). DuPage Co.: Wheaton, 3.x.1898, Gammon s.n. (F 1151567). Henry Co.: Geneseo, viii.1898, E. T. and S. A. Harper 3581 (F 1124685) and Geneseo, vii.1915, E. T. and S. A. Harper 3669 (F 1124777). Jackson Co.: Carbondale, 11.vii.1973, Heil 12 (SIU); near Grand Tower, ix.1978, Pursell s.n. (SIU); and Murphysboro, 6.vii.1985, Kubacka s.n. (SIU). Ogle Co.: South Island, Rock River, vii.1957, Voth s.n. (MICH) and White Pine Forest State Park, 1.ix.1975, Singer N 7551 (F 1020655).

Occurrence: June-October.

Substrate: Lignicolous on deciduous wood, especially elm, but also sugar maple, silver maple, red maple, beech, and oak.

Comments: *Volvariella bombycina* is the most frequently collected species of *Volvariella* in Illinois (Fig. 7).

Basidiomata of *V. bombycina* are distinctive by the large (5-20 cm diam), dry, silky-fibrillose pileus which is initially white but darkens to yellow or yellowish-brown on the disc at maturity, by the size of the basidiospores (6.5-10.5 x 4.5-6.5 µm), and by the lignicolous habitat on deciduous wood.

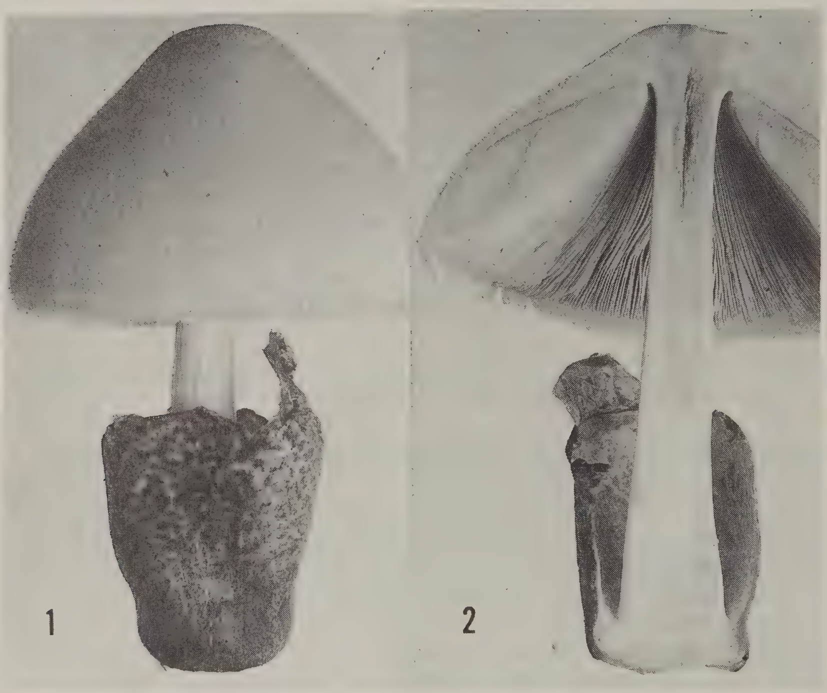
Previous reports of *V. bombycina* from Illinois include those of French (1907) from Jackson Co., Moffat (1909) from DuPage and Cook Cos., McDougall (1917) from Champaign Co., and Shaffer (1957) from Cook and McHenry Cos. Of these, only the collections cited by Shaffer were found. Our report of *V. bombycina* from Coles, DuPage, Jackson, and Ogle Counties substantially expands the voucher collection-supported geographic range of this taxon in Illinois (Fig. 7).

***Volvariella hypopithys*** (Fr.) Moser apud Gams, Kleine Kryptogamenflora, Band II: 110. 1953. Figs. 4 and 8.

Descriptive data: This taxon is adequately described by Shaffer (1957) and Orton (1986). However, our specimens are somewhat larger (pileus 5.8 cm broad and stipe 7 mm broad at the apex) than those noted by Shaffer (1957) and Orton (1986) who both reported a pileus width maximum of 5 cm and stipe width maxima of 3 and 4 mm respectively.

Specimen examined: Carroll Co.: Mississippi Palisades State Park, north of Savanna, 18.ix.1992, Sundberg 92-9-18-9 (SIU).

Substrate: Solitary in humus covered soil under mixed hardwoods.



Figs. 1-2. *Volvariella bombycina* var. *bombycina*. Harper 3669 (F 1124777). 1. Surface view. 2. Median longitudinal section. Both approximately X 2/3.

Occurrence: September.

Comments: *Volvariella hypopithys,* which might be confused with *V. pusilla* (Pers.: Fr.) Singer exhibits a dry, fibrillose-squamulose, white pileus up to 5.8 cm broad and a densely pubescent to villose stipe. The forest habitat, larger and fibrillose-squamulose pileus, and pubescent stipe distinguish *V. hypopithys* from *V. pusilla* which has a smaller stature, a glabrous pileus and stipe, and exhibits a preference for grasslands, gardens, and open soil.

This collection, found by Michael Tansey, represents the first record of *V. hypopithys* in Illinois.

***Volvariella pusilla*** (Pers.: Fr.) Singer, Lilloa 22: 401. 1951. Figs. 5 and 9.

Descriptive data: This taxon is adequately described in Shaffer (1957) and

Orton (1986). The basidiospores of the collections we examined were slightly smaller (6-7.5 x 3.5-4.5 µm) than reported by Shaffer ([4.6-] 5.4-7.9 [-8.9] x [3.4-] 4-5.7 [-6.4] µm) but longer than cited by Orton (5.5-6.5 x 4-5 µm; as *V. parvula* [Wein.] Speg.).

Specimens examined: Coles Co.: Charleston, 3.viii.1989, Methven 5788; Charleston, 17.vii.1992, Methven 6603; and Charleston , 26.vii.1992, Methven 6631 (all EIU). Jackson Co.: Midland Hills Golf Course, vicinity Carbondale, 22.ix.1980, Danley 1 (SIU). Peoria Co.: Forest Park South Nature Preserve, 29.vi.1991, Monoson 353 and Monoson 354 (both BU).

Occurrence: June-September.

Substrate: In grass or on bare soil in deciduous woods.

Comments: The basidiomata of *V. pusilla* feature a small (0.5-3 cm diam), dry, non-squamulose, white pileus with a striate margin and a glabrous stipe that is 1-5 cm long. *Volvariella hypopithys*, with which *V. pusilla* is most commonly confused, exhibits a stipe that is densely pubescent to villose and measures 2-8 cm in length and a larger (2-5.8 cm), squamulose, white to yellowish pileus which lacks a striate margin.

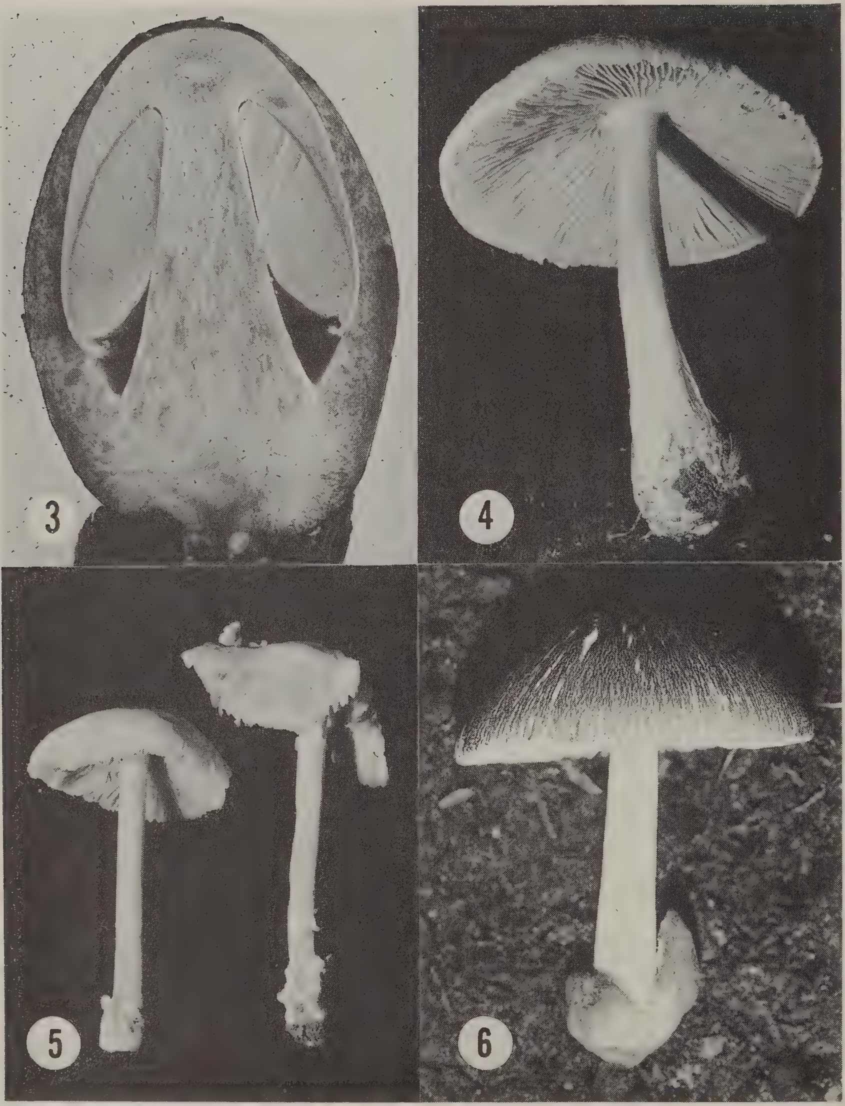
Although Moffat (1909) reported this taxon from DuPage Co., voucher collections of the material he examined could not be found. Since Shaffer (1957) did not cite collections of *V. pusilla* from Illinois, our collections represent the first voucher-supported report of this taxon from the state. The paucity of collections from Illinois (Fig. 9) is probably a result of the small, ephemeral nature of the basidiomata and absence of a collector during the short fruiting period.

Orton (1986) considered *V. pusilla* to be a synonym of *V. parvula* because "There are two taxa named *Agaricus pusillus* by Fries in Systema Mycologica 1, one in tribus *Naucoria* and the other in tribus *Volvaria*, of which the former has page priority." With recent changes in the starting date for fungi to 1753 (Greuter 1988), however, *Agaricus pusilla* Persoon (1800) becomes the earliest epithet that was applied to this taxon. As such, the correct name for this taxon is *V. pusilla*.

***Volvariella speciosa*** (Fr.: Fr.) Singer, Lilloa 22: 401. 1951. Fig. 10.

Descriptive data: This taxon is adequately described in Shaffer (1957) and Orton (1986).

Specimens examined: Cook Co.: Chicago Botanic Garden, 10.vii.1986, Farwell s.n. (F 1068465). Rock Island Co.: Port Byron, vi.1900, E. T.



Figs. 3-6. *Volvariella* spp. 3. Button of *V. bombycina* var. *bombycina*. Harper 3669 (F 1124777). Approx. X 3/4. 4. *V. hypopithys*. Sundberg 92-9-18-9. X 4/5. 5. *V. pusilla*. Methven 6603. X 1. 6. *V. volvacea*. Sundberg 84-9-1-2. X 1.

and S. A. Harper s.n. (F 1124782) and Port Byron, v.1904, E. T. and S. A. Harper s.n. (F 1090720).

Occurrence: May to July.

Substrate: Rich soil in lawns, fields, woods, and greenhouses or dung.

Comments: Shaffer (1957) recognized two varieties of this taxon, var. *speciosa* (Fr.: Fr.) Singer and var. *gloiocephala* (DC: Fr.) Singer, based on the coloration of the pileus and presence or absence of striations on the pileus margin. In the discussion which accompanied var. *gloiocephala*, Shaffer (1957) noted that "the colors are variable, integrade, and again are not correlated with presence or absence of striations". Shaffer (1957) concludes by saying that "Although specimens have been placed in either var. *speciosa* or var. *gloiocephala* on the basis of the separation given in the key, this placement has frankly been arbitrary in some cases, for the two varieties integrade to a great extent." Orton (1986) pointed out that "Greyer specimens of *V. speciosa* have been named *gloiocephala* at specific, varietal and form level, but I do not think these are taxonomically separate: they indicate variation in colour of the one species *V. speciosa*." We concur with Orton's (1986) conclusions regarding the disposition of this highly variable taxon.

The basidiomata of *V. speciosa* are distinctive by the large (5-15 cm diam), viscid pileus which ranges in color from white or cream to light brownish gray, stout stipe which is tomentose to villose basally, large basidiospores (11.5-21 X 7-12 µm), and abundant, morphologically variable pleurocystidia.

Although Moffat's (1909) report of *V. speciosa* and *V. gloiocephala* from Cook Co. were important county records, the collections apparently no longer exist and have been excluded from the distributional map for this taxon (Fig. 10). The collection from the Chicago Botanic Garden represents a new voucher-supported county record for Illinois. Although we have examined few collections of this taxon from Illinois, our data suggest that *V. speciosa* is restricted to northern Illinois.

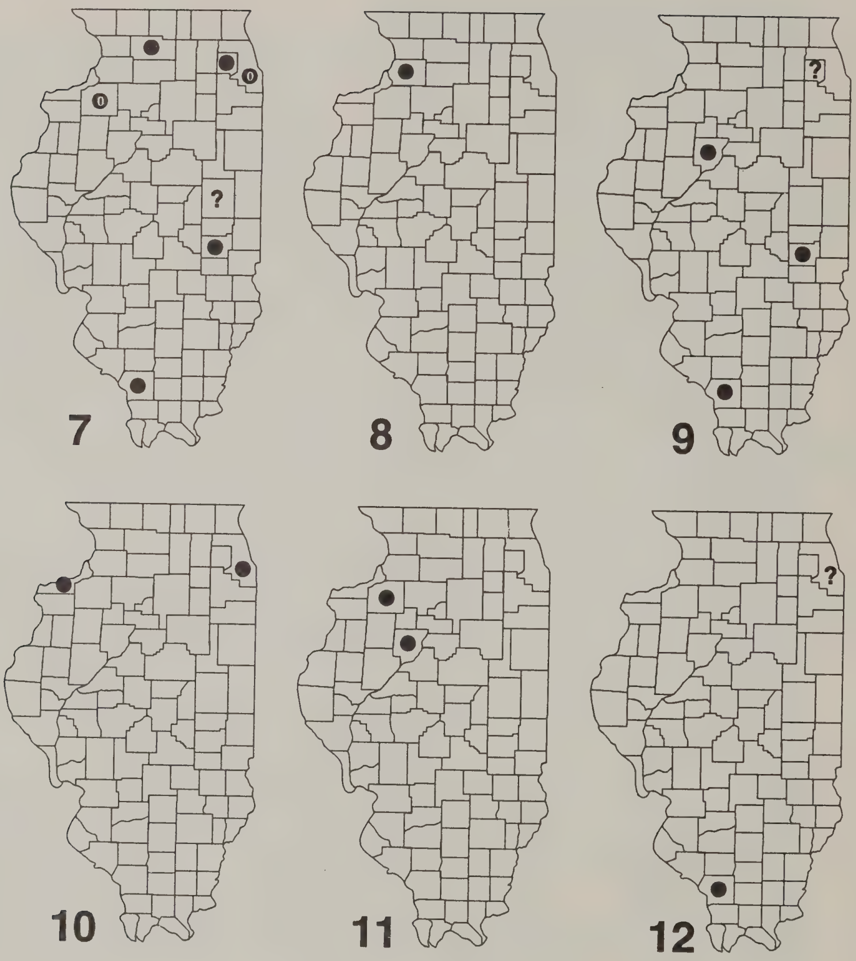
***Volvariella taylori*** (Berk.) Singer, Lilloa 22: 401. 1951. Fig. 11.

Descriptive data: This taxon is adequately described in Shaffer (1957) and Orton (1986).

Specimens examined: Henry Co.: Geneseo, viii.1915, E. T. and S. A. Harper 3703 (F 1124491). Peoria Co.: Forest Park South Nature Preserve, 29.vi.1991, Monoson 353 (BU).

Occurrence: June-August.

Substrate: Bare soil or grass.



Figs. 7-12. Distribution of *Volvariella* species in Illinois. 7. *V. bombycina* var. *bombycina*. 8. *V. hypopithys*. 9. *V. pusilla*. 10. *V. speciosa*. 11. *V. taylori*. 12. *V. volvacea*. Solid circle = new record. Hollow circle = previous record supported by voucher collection. Question mark = previous report unsubstantiated by voucher collection.

Comments: The basidiomata of *V. taylori* are characterized by a small (2-6 cm diam), fibrillose, gray to avellaneous pileus, brown to grayish brown volva, and small basidiospores (5.5-8.5 x 4-6 µm).

Our collections represent the first report of this taxon from Illinois and suggest that *V. taylori* may be restricted to northern Illinois (Fig. 11).

***Volvariella volvacea*** (Bull.: Fr.) Singer, Lilloa 22: 401. 1951. Figs. 6 and 12.

Descriptive data: This taxon is adequately described in Shaffer (1957) and Orton (1986).

Specimen examined: Jackson Co.: Little Grand Canyon, near Murphysboro, 1.ix.84, Sundberg 84-9-1-2 (SIU).

Occurrence: August to September.

Substrate: In disturbed and somewhat compacted soil.

Comments: The basidiomata of *V. volvacea* are distinctive by the large (5 cm or more in diam), dry, virgate, grayish brown to blackish brown pileus which becomes rimose at maturity, tan to dull brown innately fibrillose stipe, and brownish volva.

Although Graham (1944) reported *V. volvacea* from the Chicago region, Shaffer (1957) did not cite its presence in Illinois, and we did not locate Graham's collection. Thus, this represents the first report of *V. volvacea* from Illinois supported by an extant voucher specimen. Because Graham (1944) implied its occurrence near the Great Lakes, the geographical range of *V. volvacea* in Illinois remains unclear (Fig. 12).

## SUMMARY

To date, six species of *Volvariella* have been reported from Illinois. The occurrence and geographical distribution of the genus in Illinois is much greater than previously indicated in the literature. In our opinion, the low frequency with which *Volvariella* is collected in Illinois is a reflection of (a) the small, ephemeral nature of the basidiomata of some species, (b) the absence of collectors during periods when basidiomata are produced, and (c) undetermined but exacting microenvironmental factors required for basidiome induction or development or both. The predominance in much of the state of high grade prairie utilized in agriculture also results in a subsequent lack of forests in which some additional *Volvariella* species might occur.

## ACKNOWLEDGEMENTS

We appreciate the cooperation of Dr. Gregory Mueller (F) and Dr. Robert Shaffer (MICH) who made herbarium collections available for our study. Further, we thank Dr. Shaffer for his kindness and assistance during a visit by Dr. Methven to the Michigan Herbarium to study *Volvariella* collections. The preparation of prints by personnel at the Field Museum of Natural History in Chicago from negatives housed there was most generous. Finally, the critical and constructive comments of the reviewers--Drs. Roy Halling, Gregory Mueller, and Jack States--are also appreciated.

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# RESEARCH ON HEBELOMA (AGARICALES, CORTINARIACEAE). III. THREE NEW SPECIES FROM THE ITALIAN MIDDLE TYRRHENIAN SLOPE

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## SUMMARY

Three new species of the genus Hebeloma belonging in section Denudata are described and illustrated from Central Italy, viz. H. laetitiae, H. litoreum and H. quercetorum. Notes on the three species are provided and their taxonomic position is discussed.

KEY WORDS: Basidiomycotina, Agaricales, Cortinariaceae, Hebeloma, Taxonomy, New species, Central Italy.

## INTRODUCTION

The family Cortinariaceae Roze, especially for what concerns the three genera Cortinarius Rouss., Inocybe (Fr.) Fr. and Hebeloma (Fr.) Kumm., is well represented in the mycoflora of terricolous agaricaceous fungi inhabiting the coastal or submontane areas of the Italian Tyrrhenian slope. Most likely this is partly so because the species belonging in these three genera are hardly prized as food in the folk tradition, whereas their significance in the forest ecology is invaluable these being mostly ectomycorrhizal partners of Spermatophytes.

The phanerogamic vegetation of a few outstanding areas of the Italian middle Tyrrhenian slope, such as the Circeo National Park and the Castelporziano Presidential Estate, was fully described by Padula (1985) and Anzalone, Lattanzi & Lucchese (1990) respectively, whilst their mycoflora is rather patchily known and only recently Quadraccia & Lunghini (1990) have published a fairly exhaustive contribution concerning the Castelporziano Presidential Estate, where 641 taxa were collected, a hundred of which ascribable to the Cortinariaceae.

During our monographic investigations on the genus Hebeloma conducted in several localities in the Italian middle Tyrrhenian slope, three still undescribed species of section Denudata (Fr.) Sacc. were collected repeatedly.

All three species have been isolated in axenic cultures on "Potato Carrot Dextrose Agar" (PCDA) in view of further investigating their ectomycorrhizal relationships.

As our monographic work on this genus is still far from complete, it is our intention to publish, from time to time, preliminary contributions to it (Quadraccia, 1984, 1987, 1988).

## MATERIALS AND METHODS

Microscopical features were described using free-hand sections of basidiocarps from fresh material, mounted in $H_2O$ to detect the topography of the pigments or in Melzer's reagent, used to test a dextrinoid reaction. All microscopic measurements were made from structures mounted in 6% $NH_3 \cdot H_2O$ or in ammoniacal Congo red.

Spore dimension ranges are based on the measurement, under oil-immersion objective (x1000), of 20-30 random mature spores, taken from mounted lamellae, selected for each collection. The lenght of basidiospores includes the hilar appendix and ornamentation; the lenght of basidia does not include the sterigmata.

Microanatomical terms follow Josserand (1983) and Smith, Evenson & Mitchel (1983).

Colour terms in parentheses are those of Kornerup &

Wanscher (1978), designed as plate, column and row; other color names are not standardized. The drawings of the microscopic features were made with the aid of a camera lucida.

The specimens cited in this paper are deposited at ROHB (Holmgren, 1987).

For each species axenic cultures were grown on PCDA slants in test tubes kept in a refrigerator held at 10 ± 2 °C in darkness and deposited at ROHB culture collection.

Herbarium names are abbreviated by acronyms according to Index Herbariorum (Holmgren, Keuken & Schofield, 1981; Holmgren, 1987).

Nomenclature of vascular plants follows Pignatti (1982), and of phytosociological units Lucchese & Pignatti (1990).

## TAXONOMIC PART

Hebeloma subsectio Crustuliniformia Quadr., Doc. mycol. 14(56): 30, (1984).

**Hebeloma laetitiae** Quadraccia, sp. nov. (Figs 1, 2)

Etym.: Named in honour of my wife Mrs. Letizia Maravalli.

Pileus 20-75 mm, primitus convexus, deinde expansus, fere praeditus lato umbone obtuso, interdum subexplanato, saepius ± gibboso margine sinuato atque interdum lobato; cuticula aequali, ± minute fibrillosa, subviscosa vel viscosa, margine integro vel subcostato, pruinoso; centro cremeo-flavidus, margine roseo vel roseo-flavido sive ± uno eodemque modo albido-palaceus, colore roseo interdum tinctus, centro nonnunquam flavo-brunneus margine albido-argillaceo. Lamellae confertae, subconstrictae, emarginatae; lamellulae rotundatae, guttulas limpidas plorantes, postea brunneo maculatae; colore praeclaro, etiam in maturitate, argillaceae ex albidis, acie clariore erosa. Stipes 25-65 x 5-9 mm, rectus vel subsinuosus, cylindraceus vel ± basi expansus, firmus, plenus vel farctus; uno eodem modo tenuiter flocculosus; albus vel

albidus, subfuscescens praesertim in sporocarpibus maturitate. Cortina abest. Caro in medio pileo subtilis, alba vel albida. Odore subnullo in speciminibus recenter collectis, subraphanoideo in sectis. Sapore subraphanoideo, subamaro. Sporae (10-) 11-13 (-14) x (5-) 5.5-6.5 (-7) μm, amygdaliformes vel subcitriformes, minutim sed dense verrucosae, subflavo colore perdiluto sub microscopio optico, parum nihilve dextrinoideae. Basidia 30-38 x 8-10 μm, tetrasporica, nonnunquam bisporica. Cheilocystidia (30-) 40-65 (-80) μm, primitus sublageniformia cum apice dilatato ac ± ventricosa (usque ad 9 μm lata) postea claviformia vel subclaviformia, cum apice x 6-8 (-9) μm, parum basi dilatata (x 3-5 μm), raro bifida vel ramosa, interdum monoseptata in proximali parte. Pleurocystidia absunt. Caulocystidia cheilocystidiis similia sed longiora ac saepius cylindraceo-capitulata. Epicutis ex ixocute manifesta constituta, quae quidem ex hyphis gracilibus (x 2-4 μm) constat erectioribus, saepe in pileocystidia cheilocystidiis similia desinentibus. Cutis parum distincta ex hyphis maioribus (x 4-6 μm) constituta, recubantibus. Subcutis valde aucta, pseudoparenchymatica, ex hyphis pigmento membranario aurantiaco ± coloratis constituta.

Habitat: in silvis litoralibus planitiariis hygrophilis thermo-mesophilis sub frondosis (id est Quercus cerris, Q. robur, Q. frainetto) saepe cum Quercu ilice et Quercu subere.

Holotypus: Italia, Tenuta Presidenziale di Castelporziano (Roma), in loco dicto "Le Farniete" lectus, 30 Oct. 1986, leg. L. Quadraccia, in herbario Auctoris apud Hortum Botanicum Universitatis Romae conservatur, no. 1093 LQ (ROHB).

Isotypus: no. K(M)20801 (K).

Paratypi: no. 1080 LQ, no. 1302 LQ (ROHB).

Pileus 20-75 mm diam., at first convex to broadly convex, then expanded, nearly always with wide obtuse umbo, at times subapplanate, more often ± gibbous with margin wavy and sometimes lobate; surface uniform, ± minutely

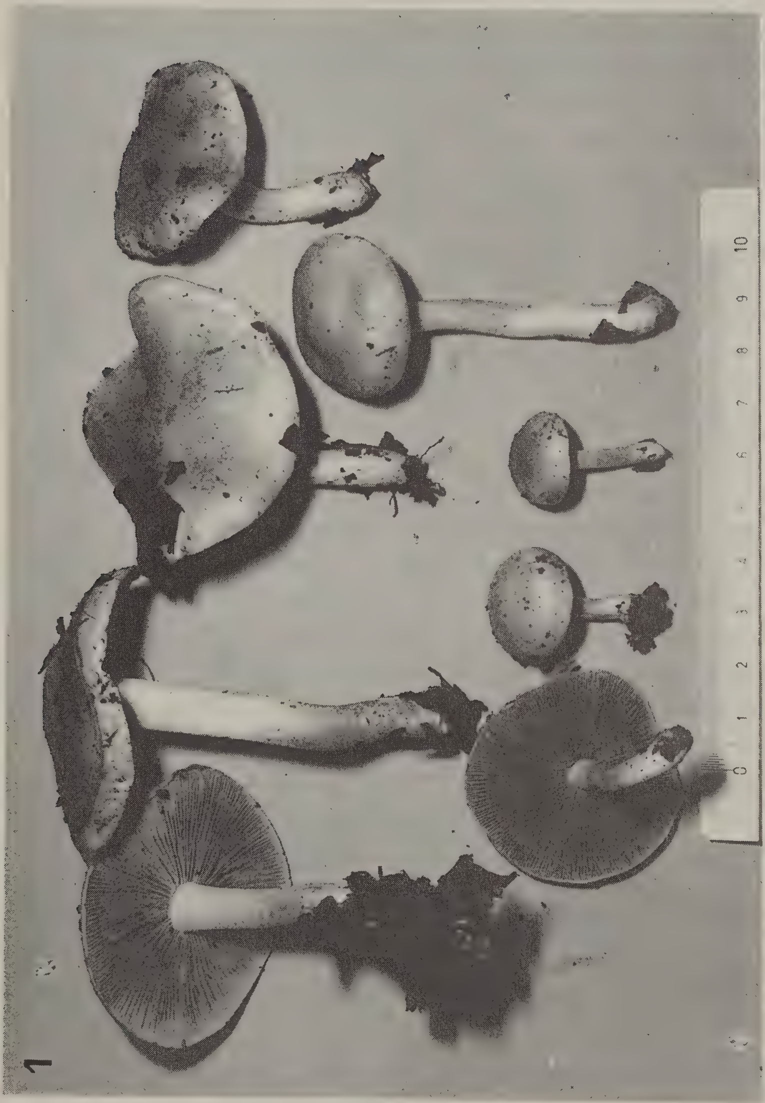
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Fig. 1. Basidiocarps of Hebeloma laetitiae (holotype, no. 1093 LQ, ROHB).

fibrillose, subviscid to viscid, margin smooth or slightly ribbed, pruinose; cream-yellowish (4A3-A4) at the centre, pinkish to yellowish-pink (5A3-A4, 6A2-A3) over the margin or ± uniformly whitish-straw coloured (3A3), with or without pinkish shades, sometimes yellowish-brown (5C7-D7) at the centre and clay-whitish on the margin. Lamellae crowded and rather narrow, emarginate, lamellulae rounded, beaded with limpid drops, becoming brown spotted as the spores mature; paler coloured even at maturity, whitish to pale argillaceous (5B3-B4), edges paler, eroded. Stipe 25-65 x 5-9 mm, straight or subsinuate, cylindraceous or ± enlarged at base, firm, solid or stuffed; finely floccose overall; white or whitish, light brownish (4B3) especially at maturity. Cortina absent. Flesh thin at pileus centre, white or whitish. Odour non distinctive in sporocarps recently collected, subraphanoid when cut. Taste subraphanoid, slightly bitter. Spores (10-) 11-13 (-14) x (5-) 5.5-6.5 (-7) µm, amygdaliform or subcitriform, minutely but densely verrucose, pale yellowish under the optic microscope, little or not dextrinoid. Basidia 30-38 x 8-10 µm, 4-spored, sometimes 2-spored. Cheilocystidia (30-) 40-65 (-80) µm, at first sublageniform with broadened apex and ± ventricose (up to 9 µm broad), later clavate or subclavate with apex x 6-8 (-9) µm, slightly expanded at the base (x 3-5 µm), seldom bifid or branched, sometimes 1-septate at the proximal part. Pleurocystidia absent. Caulocystidia similar to cheilocystidia but longer and more often cylindric-capitulate. Epicutis constituted by an evident ixocutis, formed by slender rather erect hyphae (x 2-4 µm), often ending with pileocystidia similar to cheilocystidia. Cutis hardly distinguishable formed by larger prostrate hyphae (x 4-6 µm). Subcutis evidently, pseudoparenchymatic, formed by hyphae colored with orange membranal pigment.

Habitat: in coastal damp thermo-mesophilic forests, under broadleaved trees (i.e. Quercus cerris L., Q. robur L., Q. frainetto Ten.) often with Quercus ilex L. and Q.

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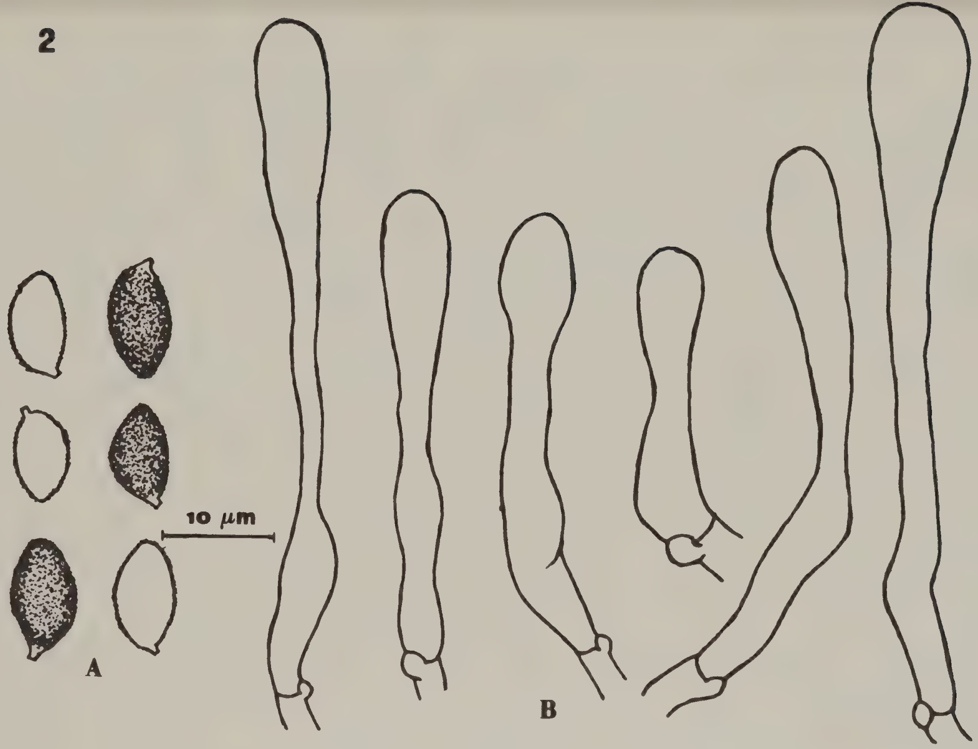

Fig. 2. A-B, Microscopic features of Hebeloma laetitiae (ex holotype). A, Basidiospores; B, cheilocystidia.

suber L.

Specimens examined:

-ITALY, Castelporziano Presidential Estate (Roma), loc. "Le Farniete" in a meso-hygrophilous wood under Quercus cerris, Q. robur, Q. frainetto, Q. ilex and Q. suber, 22 Oct. 1986, B. Anzalone & E. Lattanzi, det. L. Quadraccia, no. 1080 LQ (ROHB), paratype; ibid., 30 Oct. 1986, L. Quadraccia, no. 1093 LQ (ROHB), holotype (id., no. K(M)20801, K, isotype); Circeo National Park (Latina), loc. "Piscina delle Bagnature", in a meso-hygrophilous wood under Quercus robur, Q. cerris and Q. frainetto, 9 Nov. 1988, L. Quadraccia, no. 1302 LQ (ROHB), paratype.

Hebeloma laetitiae, to be ascribed to subsection Crustuliniformia, is a particularly beautiful species because of its pinkish-cream colour to the pileus which is unparalleled by any other Hebeloma species, a genus typically characterized by sporocarps showing dull brownish hues. However, especially in mature specimens, the pinkish tint may at times be absent, with a possible prevalence of the yellowish-brown tones, in such a case its field identification may be more difficult. Such a species has been collected only in two different coastal environments of Latium with similar vegetation type: thermophilous, meso-hygrophilous coastal woods, with a prevalence of Quercus frainetto and Q. cerris but also with Q. robur, Carpinus orientalis Miller, C. betulus L. and, sporadically Quercus ilex and Q. suber, to be ascribed to the phytosociological association Lathyro-Quercetum cerris Bonin et Gamisans. That to a certain extent H. laetitiae has a preference for meso-hygrophilous environments is borne out by the presence, in the Castelporziano biotope, of several Spermatophytes typical of wet habitats, viz. Montia fontana L. ssp. chondrosperma (Fenzl) Walters, Mentha pulegium L., Juncus conglomeratus L., J. effusus L., Beckmannia eruciformis (L.) Host, Calamagrostis epigejos (L.) Roth, Carex acutiformis Ehrh., C. riparia Curtis. In this biotope H. laetitiae has been collected in great abundance and both times there were scores of specimens growing densely gregarious. A colour plate of this species has already been published by Quadraccia & Lunghini (1990, Tav. IX, fig. a).

*Hebeloma oculatum* Bruchet, may show some affinity with *H. laetitiae*, however the latter differs in the larger size of the sporocarps, pileal colours, habitats lacking willows and size and shape of both spores and cheilocystidia. We have examined the holotype of *H. oculatum* [France, Les Echets près de Lyon (Ain), 9 Oct. 1964, BR 64-29 (LY)] finding slightly larger spores, *viz*. 9.5-12 x 5.2-6.5 µm, and cheilocystidia much longer than they were described in the original diagnosis by Bruchet (1970), *viz*. (35-) 42-85 (-130) x 4-7 µm.

*Hebeloma ingratum* Bruchet, the holotype of wich has also been studied [France, Montcharvet près de Saint-Bon (Savoie), 11 Sep. 1964, BR 64-24 (LY)], might bear some resemblance with *H. laetitiae*, but the former separates by the somewhat light-coloured and subconcolorous sporocarps, the montane or subalpine habitats mostly with *Populus tremula* L., the characteristic peppery smell, reminding that of *Asarum europaeum* L. mixed with that of *Cortinarius atrovirens* Kalchbr., the decidedly bitter taste, the typical shape of spores and shape and size of cheilocystidia.

**Hebeloma litoreum** Quadraccia, sp. nov. (Figs 3, 4)

Etym.: from the Latin, *litus* = sea coast, in reference to the specific habitat.

Pileus 15-40 (-50) mm, convexus primitus incurvo margine, postice expansus, ± centro depressus, interdum subumbilicatus, margine non parum sinuato; cuticula minute fibrillosa, subglutinosa e viscosa, margine ± pruinoso, semper costato; primitus subconcolor, brunneo-avellaneus margine clariore, postice manifeste discolor, centro avellaneus ± fuscus, cervino-pallidus in dimidia parte,

margine argillaceo-albido. Lamellae confertae, mediocriter latae, emarginatae; lamellulae sinuatae; guttulas perspicuas effluentes, postice brunneo colore maculatae; subclarae, ex albidis argillaceae, acie clariore, erosa. Stipes 20-50 x 4-9 mm, rectus vel subsinuosus, solidus, subcylindraceus vel apice parum expansus, dense uno eodem modo pruinosus, plenus vel subfistulosus; albus basi albido-argillacea. Cortina abest. Caro in medio pileo subtilis; alba vel albida. Odore nullo in speciminibus recenter collectis, in sectis odore nullo vel herbaceo. Sapore non raphanoideo, subamaro. Sporae 10-14 x 5.2-6.5 (-6.8) μm, fusiformes, dense minuteque verrucosae, interdum cum perisporio passim disiuncto, subflavae sub microscopio optico, parum nihilve dextrinoideae. Basidia 25-33 x 7.5-10 μm, tetrasporica. Cheilocystidia 20-65 μm, e lageniformibus ac ± geniculatis cum apice obtuso vel vix dilatato claviformia, numquam capitata (cum apice x 5-9 μm), ventricosa vel ad basim gradatim attenuata (x 4-9 μm), aliquando uniseptata vel biseptata. Pleurocystidia absunt. Caulocystidia cheilocystidiis paene similia, paulo longiora, interdum 1-3 septata, cylindraceo-clavata e lageniformibus, 26-70 x 5-12 μm, cum apice x 6-8 μm. Epicutis ex ixocute constituta valde aucta, quae quidem constat ex hyphis gracilibus (x 2-4 μm), saepe in pileocystidia cheilocystidiis similia desinentibus, claviformia vel cylidraceo-claviformia, subtiliora (x 3-6 μm). Cutis vix manifesta. Subcutis manifesta, quamvis parum sit aucta, ex hyphenchimate hyphoideo constituta, quod quidem ex hyphis constat pigmento membranario aurantiaco-rufo zebratis.

Habitat: in litoris arenis fruticibus semper virentibus confirmatis, sub coniferis (Juniperus, Pinus) et frondosis (Quercus), in litoris rarioribus silvis sabulosis sub Cisto salvifolio.

Holotypus: Italia, prope Parco Nazionale del Circeo (Latina), in loco dicto "Duna di S. Andrea" lectus, 16 Nov. 1988, leg. L. Quadraccia, in herbario Auctoris apud Hortum Botanicum Universitatis Romae conservatur, no. 1313 LQ

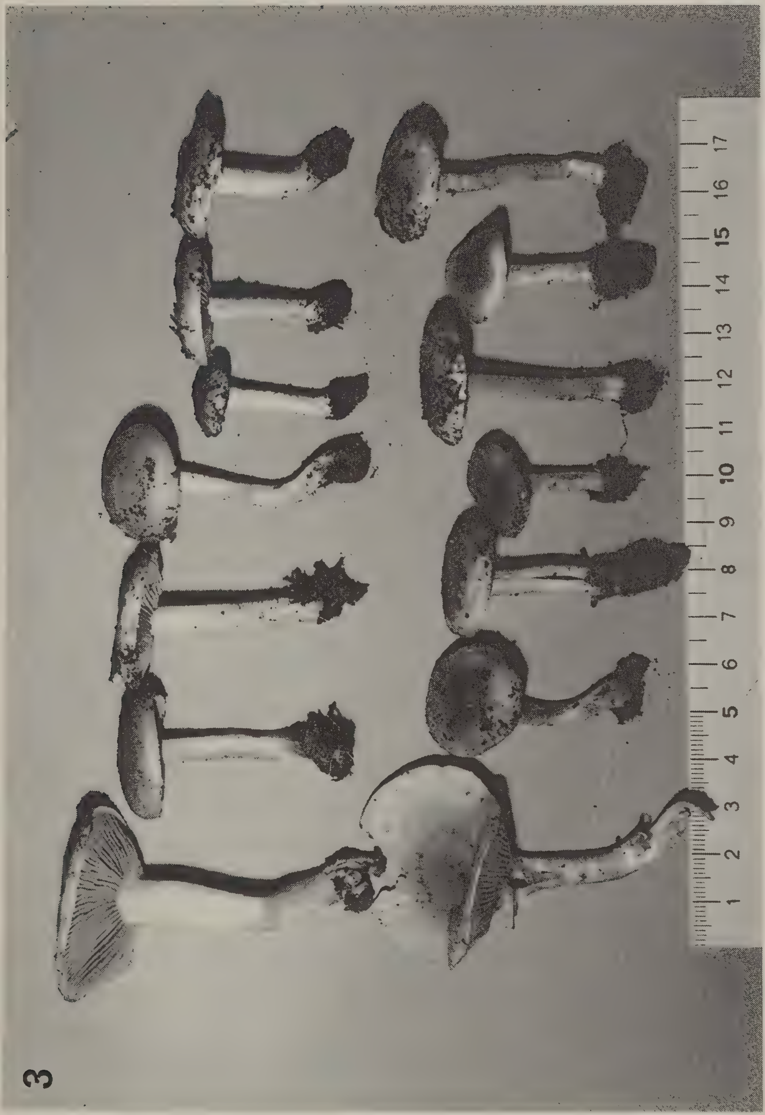
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Fig. 3. Basidiocarps of Hebeloma litoreum (holotype, no. 1313 LQ, ROHB).

(ROHB).

Isotypus: no. K(M)20802 (K).

Paratypi: no. 1221 LQ, no. 1323 LQ (ROHB).

Pileus 15-40 (-50) mm diam., at first convex with incurved margin then expanded, ± depressed at the centre, sometimes subumbilicate, margin rather wavy; surface minutely fibrillose, viscid to subglutinous, margin ± pruinose, always ribbed; at first concolorous, hazel-brown (5B3-B4) with paler margin, then distinctly discoloured, hazel ± dark at the centre (6C6, 6D7-D8), pale fawn in the half zone (5A2-A3), clay-whitish on the margin (4A2-A3). Lamellae crowded, of middle breadth, emarginate; lamellulae sinuate, beaded with limpid drops, becoming brown spotted as the spores mature; rather pale, whitish to pale argillaceous (4A2, 4B3), edges paler, eroded. Stipe 20-50 x 4-9 mm, straight or subsinuate, firm, subcylindraceous or lightly expanded at the apex, densely pruinose overall, solid or subfistulose; white, clay-whitish at the base. Cortina absent. Flesh thin at pileus centre, white or whitish. Odour not distinctive in sporocarps recently collected, not distinctive or herbaceous when cut. Taste not raphanoid, slightly bitter. Spores 10-14 x 5.2-6.5 (6.8) μm, fusiform ("naviculaire" according to Josserand, 1983), densely and finely verrucose, at times with slightly detached perispore, light yellowish under the optic microscope, hardly or not dextrinoid at all. Basidia 25-33 x 7.5-10 μm, 4-spored. Cheilocystidia 20-65 μm, lageniform and ± geniculate, with blunt or slightly broadened apex, to clavate, never capitate (apex x 5-9 μm), ventricose or gradually tapering at base, sometimes 1-2 septate. Pleurocystidia none. Caulocystidia almost like cheilocystidia, slightly longer, sometimes 1-3 septate, lageniform to cylindrical-clavate, 26-70 x 5-12 μm, apex x 6-8 μm. Epicutis a very well developed ixocutis, made up of thin hyphae (x 2-4 μm), often ending with clavate or cylindrical-clavate pileocystidia similar to cheilocystidia but thinner (x 3-6 μm). Cutis hardly observable. Subcutis

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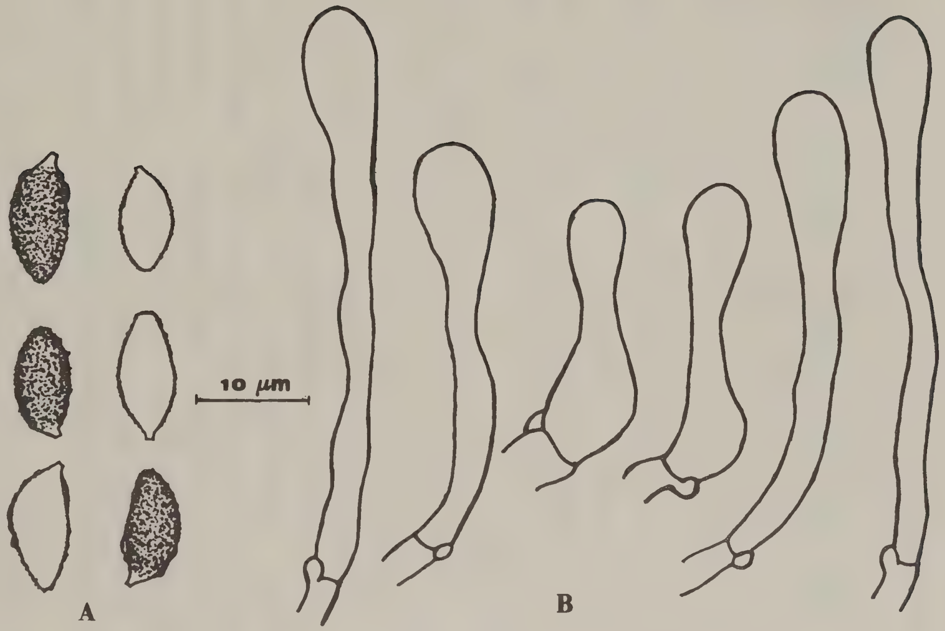

Fig. 4. A-B, Microscopic features of Hebeloma litoreum (ex holotype). A, Basidiospores; B, cheilocystidia.

prominent, even though not well developed, formed by a hyphoid layer with reddish-orange encrusting pigment.

Habitat: in coastal sand dunes with Mediterranean maquis under conifers (*Juniperus*, *Pinus*) and broadleaved trees (*Quercus*), in bare patches of sea-shore woods under *Cistus salvifolius* L.

Specimens examined:
-ITALY, Circeo National Park (Latina), loc. "Duna di S. Andrea", coastal dunes under *Quercus ilex*, *Juniperus oxycedrus* L. ssp. *macrocarpa* (Sibth. et Sm.) Ball and *Pinus pinaster* Aiton, on calcareous sand, 10 Nov. 1987, L. Quadraccia, no. 1221 LQ (ROHB), paratype; ibid. 9 Nov. 1988, L. Quadraccia, no. 1303 LQ (ROHB); ibid. 16 Nov. 1988, L. Quadraccia, no. 1313 LQ (ROHB), holotype (id., no. K(M)20802, K, isotype); Castelporziano Presidential Estate (Roma), loc. "Fontanile Pepparello", a clearing in a coastal wood of *Quercus suber* and *Q. frainetto*, under *Cistus salvifolius*, 29 Nov. 1991, L. Quadraccia, no. 1323 LQ (ROHB), paratype.

*Hebeloma litoreum* belongs in subsection *Crustuliniformia*. It is rather small-sized with a generally discolorous pileus, typically inhabiting xerophitic environments, *viz*. sandy dunes characterized by alkaline soils, very poor in nutritive elements and a sand percentage from 90 to 95% and sandy clearings in coastal woods. This species has been collected four times in seaside environments characterized by Mediterranean xeromorphic and xerophytic vegetation, typical partly of the phytosociological association *Juniperetum macrocarpae-phoeniceae* Pedrotti et Cortini Pedrotti and partly of the *Asplenio-Quercetum ilicis* Rivas Martinez.

*Hebeloma leucosarx* P.D. Orton, the holotype of which has been examined [Great Britain, Scotland, Loch Loy, Morayshire, 25 Sep. 1955, no. 593 (K)], is the only species related to *H. litoreum*, however it differs from our species in the stouter sporocarps, its growth in marshy environments in association with willows and birches, the strongly raphanoid smell, the very bitter taste, the distinctly amygdaliform spores with undetached perispore, the cheilocystidia generally shorter and above all more enlarged at apex and the pseudoparenchymatic subcutis. Incidentally, our study of the holotype of *Hebeloma lutense* Romagn., [France, forêt de Rambouillet, étang de la Tour (Seine-et-Oise), 11 Oct. 1959, no. 59.232 (PC)], persuaded us to regard it as a later synonym of *H. leucosarx*.

*Hebeloma arenosum* ["*arenosa*" *sic*] Burdsall, MacFall et Albers, apparently bears some resemblance in field characters with *H. litoreum*, but it is a typical member of subsection *Hiemalia* Quadr.

*Hebeloma* subsectio *Sinapizantia* Quadr., Doc. mycol. 14(56): 30, (1984).

**Hebeloma quercetorum** Quadraccia, sp. nov. (Figs 5, 6)

Etym.: from the Latin, *quercus* = oak, in reference to the specific habitat.

Pileus 25-75 mm, e subconvexo explanato-convexus vel passim explanatus, interdum depressus, margine ± sinuoso, inflexo ex incurvo; cuticula laevigata vel corrugata, centro praesertim, sicca vel subviscosa, hygrophana saepe rore albido nitente, margine laevigato vel subcostato; siccus uno eodem modo cremeo-albidus, cremeo-flavus vel crustulinus, udus subgriseus vel griseo-brunneus ± fuscus, exarescens discolor, centro obscuriore vel in media parte zonato, margine paulo clariore. Lamellae confertae ac sublatae (x 6-9 mm), rotundato sinuatae, lamellulae rotundatae; siccae, sporis numquam maculatae; ex albido-avellaneis, interdum colore carneo dilutis, subbrunneae, acie paulo clariore vel subconcolori, erosa. Stipes 35-90 (-125) x 5-10 (-12) mm, subcylindraceus, rectus vel subsinuosus, bulbo praeditus excentrico (usque ad 17 mm lato); fibrosus ac fragilior, fistulosus, intus cuspide

apicali praeditus, apice pruinosus, alibi in longitudinem fibrillosus; candidus, sericeus, tactu fuscescens. Cortina abest. Caro in medio pileo ac super lamellas subtilis. Odore nullo vel subraphanoideo in speciminibus recenter collectis, raphanoideo vel herbido-raphanoideo in sectis. Sapore subraphanoideo subamaro. Sporae (9-) 10-13 (-14) x 6-7 (-7.5) µm, subcitriformes e amygdaliformibus, valde ac dense verrucosae, interdum cum perisporio passim disiuncto, subflavae sub microscopio optico, non dextrinoideae. Basidia 25-30 x 7-9 µm, tetrasporica. Cheilocystidia (25-) 30-80 (-85) µm, e lageniformibus cum apice obtuso vel subcapitulato, subcylindracea cum apice ± dilatato (x 4.5-9 µm lato), basi plerumque ± ventricosa (x 4-9 µm). Pleurocystidia absunt. Caulocystidia cheilocystidiis similia, sed usque ad 120 µm longa, plerumque lageniformia cum apice obtuso et basi ventricosiora (x 10-15 µm). Epicutis ex ixocute parum aucta constituta, quae quidem ex hyphis constat gracilibus (x 3-4 µm), saepe in pileocystidia claviformia vel sublageniformia desinentibus. Cutis vix manifesta. Subcutis bene aucta, clare pseudoparenchimatica, ex hyphis aurantiacis constituta propter pigmentum membranarium incrustans.

Habitat: in silvis deciduis, praecipue quercinis, litoralibus vel submontanis, thermo-mesophilis vel mesophilis (id est Quercus robur, Q. cerris, Q. frainetto) sed etiam Carpinus betulus cum Carpino orientali, Ostrya carpinifolia vel rarius cum Castanea sativa.

Holotypus: Italia, prope Parco Nazionale del Circeo (Latina), in loco dicto "Piscina delle Bagnature" lectus, 10 Nov. 1987, leg. L. Quadraccia, in herbario Auctoris apud Hortum Botanicum Universitatis Romae conservatur, no. 1218 LQ (ROHB).

Isotypus: no. K(M)20803 (K).

Paratypi: no. 1219 LQ, no. 1226 LQ (ROHB).

Pileus 25 -75 mm diam., subconvex to plano-convex or irregularly applanate, at times depressed, margin ± wavy, incurved to inflexed; surface smooth or wrinkled,

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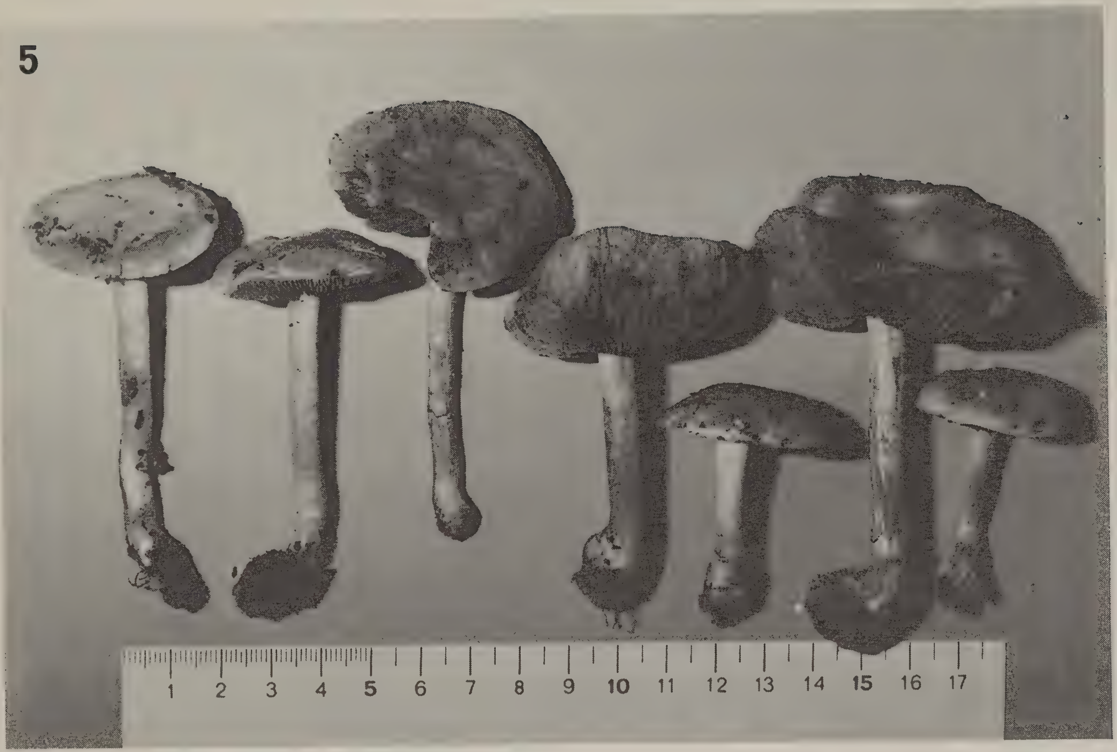
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Fig. 5. Basidiocarps of Hebeloma quercetorum (holotype, no. 1218 LQ, ROHB).

especially at disc, dry or subviscid, often hygrophanous with a hoary look, margin smooth or subribbed; when dry of a uniform whitish-cream (4A2-A3), yellowish-cream (4A5) or orange cream (6B4-B5) colour, when damp greysh (6C4-D4) or brownish-grey (6D6-E6) ± dark, during dehydration discolorous, darker at disc or zonate over the inner limb, margin slightly lighter. Lamellae crowded and somewhat broad (x 6-9 mm), rounded with decurrent tooth, dry and never spotted; whitish-hazel (5C4-C5), at times with pinkish shade (6B4-B5), to light brown (7C5), edge slightly lighter or subconcolorous, eroded. Stipe 35-90 (-125) x 5-10 (-12) mm, subcylindrical, straight or slightly wavy, with an excentric bulb (up to 17 mm broad); fibrous and rather brittle, fistulose, with apical appendage; pruinose at apex, elsewhere lengthwise fibrillose; pure white, silky, becoming brown on handling. Cortina absent. Flesh thin both at pileus centre and on lamellae. Odour lacking or slightly raphanoid when collected, raphanoid or herbaceous-raphanoid on cutting; Taste bitterish subraphanoid. Spores (9-) 10-13 (-14) x 6-7 (-7.5) µm, amygdaliform to subcitriform, roughly and densely verrucose, at times with perispore just detached in some spots, light yellowish under the light microscope, not dextrinoid. Basidia 25-30 x 7-9 µm, 4-spored. Cheilocystidia (25-) 30-80 (-85) µm, lageniform, with blunt or subcapitulate apex, to subcylindrical with ± broadened apex (apex x 4.5-9 µm broad), generally ventricose at base (x 4-9 µm). Pleurocystidia absent. Caulocystidia like cheilocystidia but up to 120 µm long, generally lageniform, with blunt apex and more ventricose at base (x 10-15 µm). Epicutis a poorly developed ixocutis formed by thin hyphae (x 3-4 µm), often ending with clavate or sublageniform pileocystidia. Cutis not observable or hardly visible. Subcutis a well developed pseudoparenchymatic layer with orange encrusting pigment.

Habitat: in coastal or submontane thermo-mesophilous or mesophilous deciduous forests, especially oak-woods with

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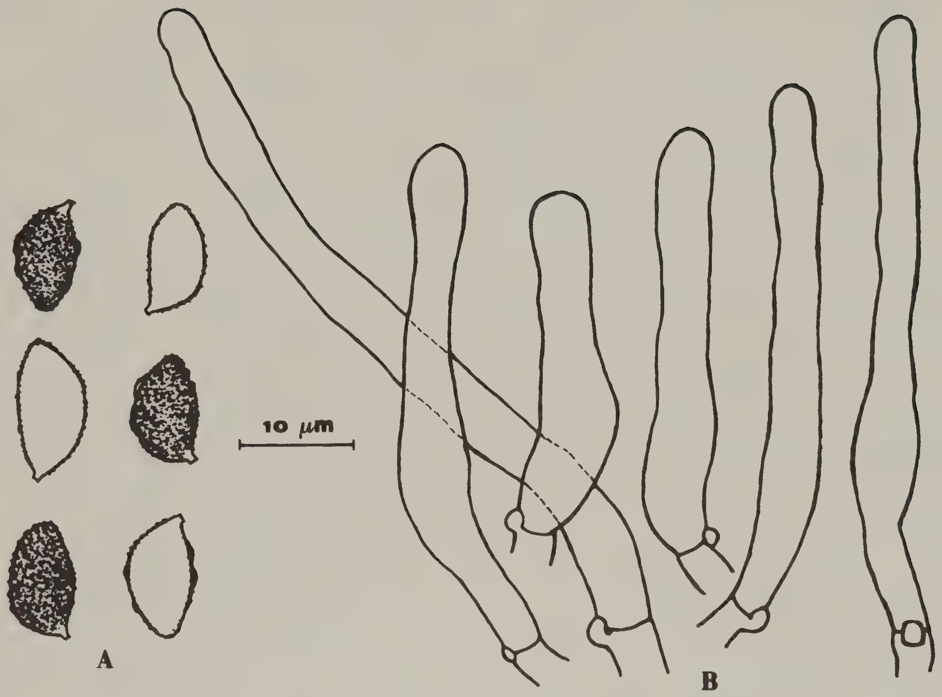

Fig. 6. A-B, Microscopic features of Hebeloma quercetorum (ex holotype). A, Basidiospores; B, cheilocystidia.

*Quercus robur*, *Q. cerris*, *Q. frainetto*, occasionally with *Carpinus betulus*, *C. orientalis*, *Ostrya carpinifolia* Scop. and rarely *Castanea sativa* Miller.

*Specimens examined*:

-ITALY, Grottaferrata (Roma), wood of *Castanea sativa*, 25 Sep. 1984, L. Perrone, det. L. Quadraccia, no. 877 LQ and no. 878 LQ (ROHB); Bosco di Manziana (Roma), under *Quercus cerris* and *Q. frainetto*, 16 Oct. 1984, L. Quadraccia, no. 924 LQ (ROHB); Tenuta di Capocotta (Roma), mixed wood with oaks, 4 Nov. 1984, L. Perrone, det. L. Quadraccia, no. 943 LQ (ROHB); Circeo National Park (Latina), loc. "Piscina delle Bagnature", meso-hygrophilous wood with *Quercus cerris*, *Q. frainetto*, *Q. robur*, *Carpinus betulus* and *C. orientalis*, 10 Nov. 1987, L. Quadraccia, no. 1218 LQ (ROHB), holotype (id. no. K(M)20803, K, isotype) and no. 1219 LQ (ROHB), paratype; Bosco di Manziana (Roma), under *Quercus cerris*, *Q. frainetto* and *Ostrya carpinifolia*, 16 Nov. 1987, L. Quadraccia, no. 1226 LQ (ROHB), paratype; Tre Cancelli (Roma), under *Quercus cerris*, 28 Oct. 1989, L. Quadraccia, no. 1304 LQ (ROHB); Circeo National Park (Latina), loc. "Selva Piana", under *Quercus robur* and *Q. cerris*, 20 Oct. 1990, L. Quadraccia, no. 1317 LQ (ROHB); Castelporziano Presidential Estate (Roma), loc. "Il Pizzuto", meso-hygrophilous wood with *Quercus robur*, *Q. cerris* and *Q. frainetto*, 29 Oct. 1991, L. Quadraccia, no. 1321 LQ, no. 1322 LQ and no. 1324 (ROHB).

*Hebeloma quercetorum* is a species of subsection *Sinapizantia*, characterized by the rather large size, with a weakly viscid typically hygrophanous pileus, which is hoary and often wrinkled, whitish-hazel or light brown lamellae, at times with a pinkish flush, stipe rather long as compared to pileus diameter and often with an excentric bulb, spores amygdaliform to subcitriform, rather large, densely verrucose and with perispore which occasionally comes slightly loose, cheilocystidia lageniform or subcylindrical subcapitulate and habitat typically in oak-woods. The hygrophanous pileus, something of a rarity in the genus *Hebeloma*, often allows its identification in the field. This species, has often been collected in scores, in all deciduous oak-woods of the Tyrrhenian coast of Latium personally visited by the author, while its collection under *Castanea sativa*, not made by us, needs confirmation as to the exact floristic composition of the habitat, as some *Quercus* spp. might be sporadically present. A colour plate of *H. quercetorum* was published in Quadraccia & Lunghini (1990, tav. IX, fig. b).

*Hebeloma sinapizans* (Paul.) Gill. may look vaguely like *H. quercetorum*, however the former is different in colour and shape of sporocarps, the striking raphanoid smell and the taste likewise raphanoid and bitter and, above all, in microscopic features such as the larger, strongly dextrinoid spores with almost smooth snoutlike apex and the distinctly lageniform cheilocystidia.

*Hebeloma brunneifolium* Hesler shows some affinity with *H. quercetorum*; unfortunately we have not been able to examine the type collection of the former species as our request to TENN has had no answer thus far. At any rate, according to Hesler's (1977) description, *H. brunneifolium* has smaller basidiocarps (pileus 25-40 mm and stipe 40-70 x 4-6 mm), a cinnamon buff pileus, much darker, "*rhamneo-brunneae*" lamellae (*inde nomen*), odour and taste both raphanoid, subfusoid and calyptrate spores and incredibly long caulocystidia, *viz*. 150-230 x 5-8 µm. In addition, Hesler (1977) reports no information as to the habitat of this species.

*Hebeloma subsaponaceum* P. Karst. seems to be allied to *H. quercetorum*, from which it differs in having smaller size of the basidiocarps with slender stipe lacking the bulb, smaller spores, *viz*. 8.5-11 x 5-6 µm, cheilocystidia different in shape and size, and different ecology.

## ACKNOWLEDGEMENTS

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Middle Tyrrhenian slope". I would like to thank the Directors, Curators and person of the following Herbaria for the loan of material: Prof. G. Bruchet (LY), Prof. H. Romagnesi (PC), Dr. D.N. Pegler (K). Furthermore, Prof. R. Dell'Orbo (Rome) is thanked for his collaboration to the Latin descriptions and Prof. E. Grilli (Popoli) is thanked for his help in the English translation. I wish to thank the Directions of the Castelporziano Presidential Estate and Circeo National Park for kind permission to carry out mycological researches in their respective territories. Finally, I am grateful to Prof. H. Romagnesi (Paris) for critical review of this paper.

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# NEOTYPIFICATION OF *ROSELLINIA BUXI* FABRE

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## SUMMARY

The occurrence of *Rosellinia buxi* in Europe is briefly discussed. Due to the loss of any original material of this species, a neotype for *Rosellinia buxi* is designated.

Keywords: *Rosellinia buxi*, neotype, taxonomy.

*Rosellinia buxi* was described by Fabre (1878) based on a specimen collected on *Buxus sempervirens* L. in Southern France, Vaucluse, Sérignan. Viennot–Bourgin (1949) mentioned this species as a pathogen developing and fruiting at the base of the stems and roots of *B. sempervirens* and causing loss of leaves and slow rotting of the whole host plant, which can lead to its death after two to three years. The disease was observed in a *B. sempervirens* plantation in Grignon in the region of Versailles, Paris, France (Viennot–Bourgin, 1949). Recently, *R. buxi* was collected again by F. Candoussau and N. de Munnik in Southern France on *B. sempervirens* forming hedges at four different sites in the Departement Ariège.

All localities are situated on limestone and characterized by high rainfall (average 1200 mm per year); the average temperature during the year is 12.5 C. Outside France, two collecting sites in Great Britain, also only on *B. sempervirens*, are known:

in Buckinghamshire, Ellesborough Warren (A.J.S. Whalley, pers. comm.), and in Surrey, Mickleham, Box Hill. In addition, *R. buxi* is also reported from Georgia, C.I.S. (Whalley & Hammelev, 1988).

Original material or a type specimen is lacking in Fabre's herbarium at Sérignan–du–Comptat, France, and at PC (Petrini, 1992). Petrini (1992) refrained from designating a neotype, because at that time no recent French material was available. With the discovery of four new sites in Southern France, and due to the abundance of material collected there, it now seems appropriate to designate a neotype of *Rosellinia buxi*. Effforts to obtain cultures from the freshly collected material failed.

***Rosellinia buxi* Fabre, Ann. Sci. Nat. Sér. VI. 9: 78. 1878.**

Subiculum dark brown, woolly to hyphal, well developed, embedding completely the lower part of stromata, persistent, developing up to 1125 µm high synnemata.– Stromata 1.2–1.4 mm diam, 1.2–1.5 mm high, almost globose to semiglobose with finely papillate to pointed ostioles, gregarious.– Asci not seen.– Ascal plugs 5.5–6.5 µm high, upper width 4.5–5 µm, lower width 3–3.5 µm.– Ascospores 22–31 x 6.5–8 µm, narrowly ellipsoidal to broadly fusiform, dark brown; germ slit 9–15.5 µm long, straight.

Neotype.– On *Buxus sempervirens*; FRANCE: Ariège, 20 km east of St. Girons, Commune d'Esplas de Sérou, Coume de Roux, 750 m. a. s., 16. VI. 1992, N. de Munnik (3.186, ZT, duplicates at PC, K).

Other collections examined.– on *Buxus sempervirens*; FRANCE: Ariège, Commune d'Esplas de Sérou, Coume de Roux, 750 m. a. s., 12. IV. 1992, F. Candoussau & N. de Munnik (3.185, ZT); same locality, 11. X. 1992, N. de Munnik (3.188, ZT); Commune de Castelnau Durban, Poug Gariné, 600 m. a. s., 14. IV. 1992, F. Candoussau & N. de Munnik (3.187, ZT); Commune de Castelnau Durban, Lasserre, 650 m. a. s., 14. IV. 1992, F. Candoussau & N. de Munnik (3.189, ZT).

Detailed description and illustration.– Petrini (1992).

## Acknowledgments

We thank Mr. N. de Munnik for reporting the collecting sites of *Rosellinia buxi* and for the gift of material. Drs A. J. S. Whalley and E. Horak kindly provided pre–submission review.

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# NEW SPECIES OF CRYPTOPHIALE FROM NEW ZEALAND AND NEW CALEDONIA

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## Abstract

Two new species of *Cryptophiale*, found during a study of dematiaceous hyphomycetes on dead leaves of various plants are described and figured: *C. pusilla* on *Astelia* sp. and on *Gahnia setifolia* (A. Rich.) Hook. f. from New Zealand, and *C. orthospora* on *Elaeocarpus dentatus* (J.R. & G. Forst.) Vahl and *Metrosideros kermadecensis* W.R.B. Oliver from New Zealand and on *Gahnia* sp. from New Caledonia. *C. manifesta* Sutton & Hodges and *C. udagawae* Pirozynski & Ichinoe are recorded for the first time from New Zealand and New Caledonia, respectively.

## Introduction

During examination of dead leaves, several collections of *Cryptophiale* Pirozynski were found of which two, from New Zealand and from New Caledonia, are distinct new species and are described and figured in this paper. Two other species are newly recorded from these countries.

**Cryptophiale pusilla** McKenzie sp. nov. Fig. 1

Coloniae conspicuae, effusae. Conidiophora e cellulis rubro-brunnea, macronematosa, mononematosa, singula, eramosa, erecta, recta vel parum curvata, laevia, septata, rubro-brunnea, apicem versus parce pallidiora, apice acuta, usque ad 175 μm longa, ad basim 4-6.5 μm lata, ad apicem 1-1.5 μm. Zona fertilis ultramediana, scutelliformia, 13-36 μm longa, 9.5-15 μm crassa; cellulae conidiogenae scutello cellularum sterilium pallide fusco celatae; cellulae steriles 5-8 μm longae, 1.5-4 μm latae. Conidia hyalina, adherentia, curvata vel falcata, filiformia, laevia, eseptata, (5.5-) 7.5-10.5 (-12) x c. 0.25 μm.

In foliis mortuis *Astelia* sp. (Liliaceae) et *Gahnia setifolia* (A. Rich.) Hook. f. (Cyperaceae).
Holotypus PDD 60751.

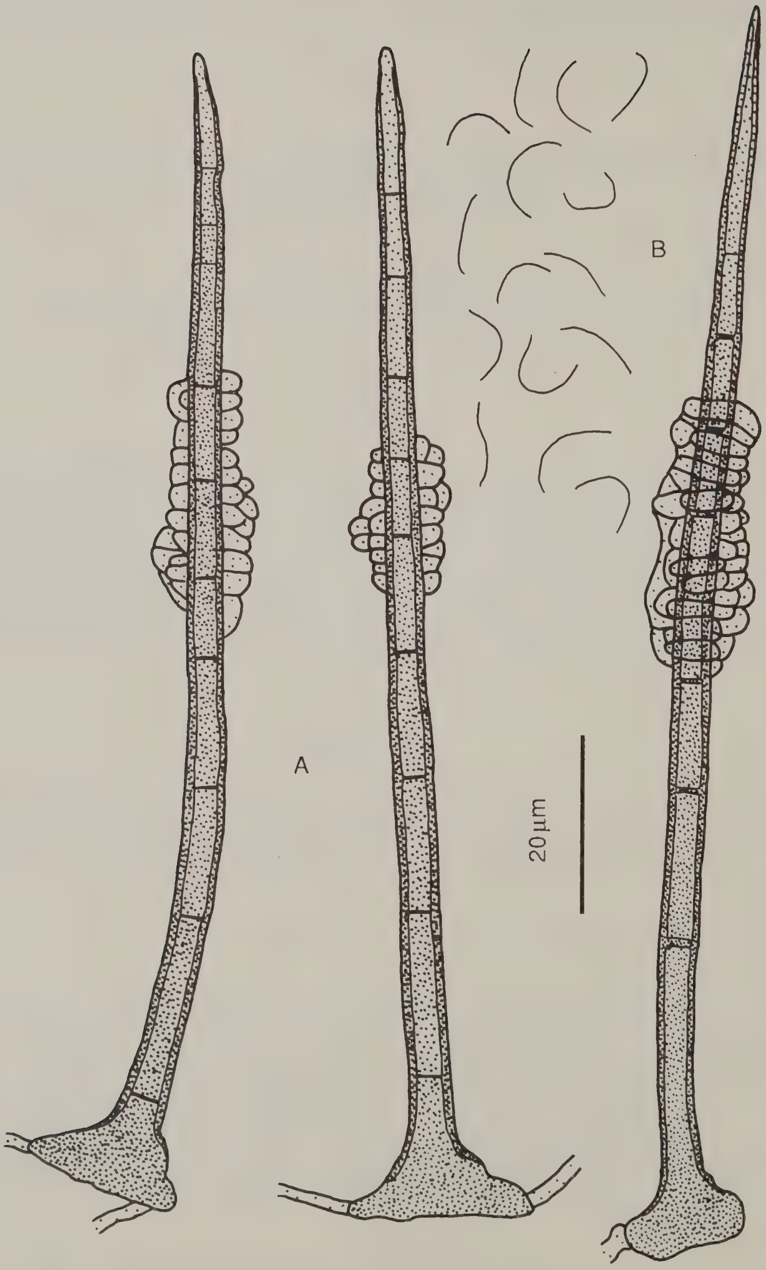

Figure 1 *Cryptophiale pusilla*, conidiophores and conidia (A, PDD 60750; B, PDD 60751 - type). Specimens mounted in hydrous lactophenol.

Colonies conspicuous, effuse. Conidiophores setiform, arising from reddish-brown, smooth, swollen cells, macronematous, mononematous, single, unbranched, erect, straight or slightly curved, smooth, septate, reddish-brown, slightly paler towards the acute apex, up to 175 μm long x 4-6.5 μm thick near the base, tapering to 1-1.5 μm near the apex. Fertile region 13-36 μm long, 9.5-15 μm wide, usually more than halfway up the conidiophore, base to fertile region 40-95 μm, apex to fertile region 35-60 μm. Conidiogenous cells obscured by a shield of sterile, pale brown cells; each shield cell 5-8 μm long, 1.5-4 μm wide. Conidia produced in slime and adhering to the fertile part of the conidiophore in a lateral droplet; hyaline, curved or falcate, filiform, smooth, not appearing septate, (5.5-) 7.5-10.5 (-12) x c. 0.25 μm.

Specimens examined:
On *Astelia* sp.
New Zealand, Coromandel, Little Barrier Island, Thumb Track, 6.IV.1988, E.H.C. McKenzie (PDD 60752).
On *Gahnia setifolia* (A. Rich.) Hook. f.
New Zealand, Auckland, Waitakere Ranges, Walker's Bush, 4.VIII.1982, E.H.C. McKenzie (PDD 60750); Waitakere Ranges, Turanga Road, 1.IX. 1992, E.H.C. McKenzie (PDD 60751 - **holotype**).

The specific epithet refers to the small size of this species, especially the conidia.

This species has the smallest conidia of any known *Cryptophiale*. The conidiophores and fertile region are also smaller than in most other species. In general morphology and in conidial size it approaches *C. minor* Farr (1980), but the latter has differently shaped conidia which measure 12-14 (-16) μm long x up to 1.2 μm wide.

### **Cryptophiale orthospora** McKenzie sp. nov. Fig. 2

Coloniae conspicuae, effusae. Conidiophora e cellulis rubro-brunnea, macronematosa, mononematosa, singula, eramosa, erecta, recta vel curvata, laevia, septata, rubro-brunnea, apicem versus parce pallidiora, acuta, usque ad 470 μm longa, ad basim 8.5-11.5 μm lata, ad apicem 5-8 μm. Zona fertilis subapicalis, scutelliformia, 45-75 μm longa, 12-16.5 μm crassa; cellulae conidiogenae scutello cellularum sterilium pallide fusco celatae; cellulae steriles 2.5-5 μm latae, extendentes 3-5.5 μm ultra conidiophororum parietem. Conidia hyalina, adherentia, cylindrica vel obclavata, recta vel parvum curvata, laevia, 1-septata, (14-) 17-24 (-26.5) x (1.5-) 1.75-2.25 (-2.5) μm, apice acuta, basi rotundata vel obconice truncata.

In foliis mortuis *Elaeocarpus dentatus* (J.R. & G. Forst.) Vahl (Elaeocarpaceae), *Gahnia* sp. (Cyperaceae) et *Metrosideros kermadecensis* W.R. B. Oliver (Myrtacceae).
Holotypus PDD 60838.

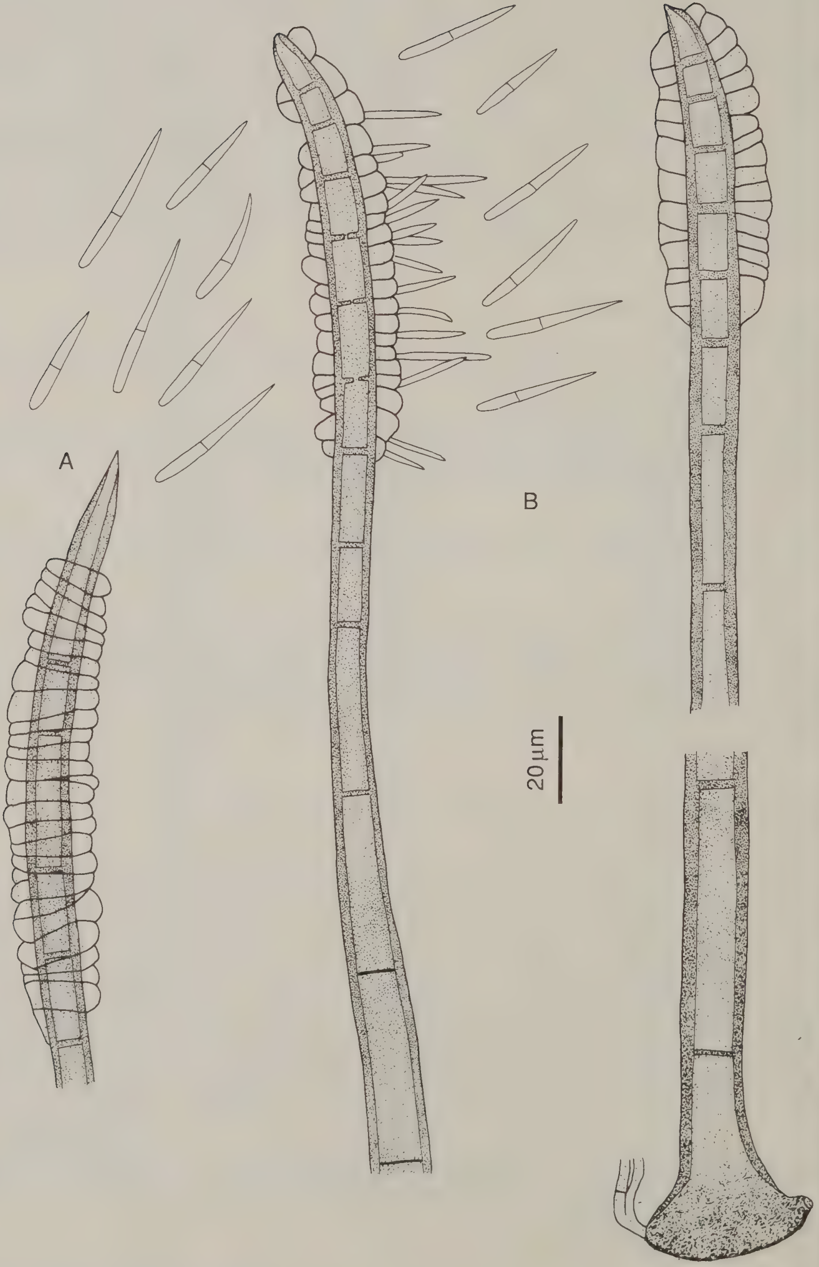

Figure 2 *Cryptophiale orthospora*, conidiophores and conidia (A, PDD 60838 - type; B, PDD 60753). Specimens mounted in hydrous lactophenol.

Colonies conspicuous, effuse. Conidiophores arising from reddish-brown, smooth, swollen cells, macronematous, mononematous, single, unbranched, erect, straight or curved, smooth, septate, reddish-brown, slightly paler towards the acute apex, up to 470 $\mu$m long x 8.5-11.5 $\mu$m thick near the base, tapering to 5-8 $\mu$m in the fertile region. Fertile region subapical, 45-75 $\mu$m long, 12-16.5 $\mu$m wide, base to fertile region 90-200 $\mu$m, apex to fertile region 7-16 $\mu$m. Conidiogenous cells obscured by a shield of sterile, pale brown cells; each shield cell 2.5-5 $\mu$m wide, extending 3-5.5 $\mu$m beyond the conidiophore wall. Conidia produced in slime and adhering to the fertile part of the conidiophore in a lateral droplet; hyaline, cylindrical or obclavate, straight or slightly curved, smooth, 1-septate, (14-) 17-24 (-26.5) x (1.5-) 1.75-2.25 (-2.5)$\mu$m, apex acute, base rounded or obconically truncate.

Specimens examined:
On *Elaeocarpus dentatus* (J.R. & G. Forst.) Vahl
New Zealand, Northland, Omahuta State Forest, 22.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 60838 - **holotype**).
On *Gahnia* sp.
New Caledonia, Mt des Koghis, 15.XI.1987, E.H.C. McKenzie (PDD 60753).
On *Metrosideros kermadecensis* W.R.B. Oliver
New Zealand, Kermadec Islands, Raoul Island, IX.1988, E.H.C. McKenzie (PDD 59365).

The specific epithet refers to the straight conidia; most other *Cryptophiale* species have variously curved conidia.

The conidia of *C. orthospora*, though very similar to those of *C. manifesta* B. Sutton & Hodges, are more robust, with the fertile region just below the apex rather than in the middle third of the conidiophore. The conidiogenous cells of *C. manifesta* are conspicuous, whereas they are obscured by the shield cells in *C. orthospora*.

Including these two new species, there are now 14 known species of *Cryptophiale*. Sutton et al. (1989) provided a key to nine species, and since then 3 others have been described. These are *C. insularis* McKenzie (1993) on *Dracophyllum arboreum* Ckn., from Chatham Islands, New Zealand, and *C. caudata* and *C. novae-caledoniae* McKenzie & Kuthubutheen (1993) on *Freycinetia* spp. from Malaysia and New Caledonia, respectively.

To date, the only published records of *Cryptophiale* species from New Zealand or New Caledonia are of *C. insularis* and *C. novae-caledoniae*. Two additional species, known to be widely distributed in tropical and subtropical regions, have also been found.

**Cryptophiale manifesta** B. Sutton & Hodges, *Nova Hedwigia 27*: 343, 1976

Specimen examined:
On *Dracophyllum* sp.

New Caledonia, Mt des Koghis, 15.XI.1987, E.H.C. McKenzie (PDD 60848).

Although this collection has been placed in *C. manifesta*, it differs in some ways. Sutton & Hodges (1976) describe the fertile region of *C. manifesta* as restricted to the middle third of the conidiophore, leaving the upper and lower thirds sterile. In the New Caledonian fungus the fertile region is usually more than halfway up the conidiophore; the fertile region is 39-50 μm long, beginning 100-110 μm from the base of the conidiophore and ending 50-60 μm below the top. The conidia of *C. manifesta* are 22-27 μm long and straight or with a tendency to become falcate. Those of the present collection are shorter at (15.5-) 18-20.5 (-21.5) μm and are mainly falcate, rarely straight.

**Cryptophiale udagawae** Pirozynski & Ichinoe in Pirozynski, *Canadian Journal of Botany 46*: 1126, 1968

Specimens examined:
On *Knightia excelsa* R. Br.
New Zealand, Waitakere Ranges, Anawhata Road, 1.I.1974, W.B. Kendrick (PDD 40480). Bay of Plenty, Rotorua, Hongi's Track, 12.I.1974, W.B. Kendrick (PDD 40535).
On *Pseudopanax crassifolius* (Sol. ex A. Cunn.) C. Koch
New Zealand, Auckland, Waitakere Ranges, Piha Road, III.1976, E.H.C. McKenzie (PDD 34696).

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# THE GENUS ACOMPSOMYCES (LABOULBENIALES, ASCOMYCOTINA) IN SPAIN

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## ABSTRACT

One new species of *Acompsomyces* parasitizing beetles from Spain is described: *Acompsomyces ootypi* on *Ootypus globosus* (Coleoptera Cryptophagidae). Some aspects concerning the morphology, variability, host range and other features of *Acompsomyces* species known from Spain are given. Three species of *Acompsomyces*, *A. brunneolus*, *A. corticariae* and *A. pauperculus* are here reported for the first time for Spain as well for the European continent. The Iberian species are compared with the other known species of *Acompsomyces*. In addition, the perithecial apex structure of the species of this genus is discussed.

## RESUMEN

Se describe una especie nueva de *Acompsomyces* parásita de coleópteros de España: *Acompsomyces ootypi* sobre *Ootypus globosus* (Coleoptera Cryptophagidae). Se comentan aspectos concernientes a la morfología, variabilidad, hospedantes y otras características de las especies de *Acompsomyces* ibéricas. Se citan por primera vez para España y para el continente europeo tres especies de *Acompsomyces*: *A. brunneolus*, *A. corticariae* y *A. pauperculus*. Las especies ibéricas se comparan con las otras del género *Acompsomyces*. Además, se discute la estructura del ápice peritecial de las especies de este género.

## INTRODUCTION

The genus *Acompsomyces* was described by Thaxter (1901) with a single species, *Acompsomyces corticariae* Thaxt., based on a single mature individual found on *Corticaria* (Coleoptera Lathridiidae) from U.S.A. Later, the same author (Thaxter, 1902, 1905) described three more species (*Acompsomyces atomariae* Thaxt., *A. pauperculus* Thaxt. and *A. brunneolus* Thaxt.). Spegazzini (1917) recorded *A. brunneolus* from Argentina (probably an error for *A. corticariae* according to Benjamin, 1989) and described two additional species, *Acompsomyces decarthricola* Speg. and *A. platensis* Speg., parasitic on Pselaphidae (Coleoptera). Some years later, Spegazzini's species were transferred to *Autophagomyces* by Thaxter (1931). Tavares (1985) transferred two species originally placed in *Stigmatomyces* (*S. stenichni* Scheloske and *S. lasiochili* Thaxt.) to *Acompsomyces*. Majewski (1986) reported *Acompsomyces atomariae* Thaxt. from Poland. Benjamin (1989) revised the generic limits of the genus, described a new species (*Acompsomyces parvus*), and excluded *A. stenichni* (Scheloske) I.I.Tav. and *A. lasiochili* (Thaxt.) I.I.Tav. from the genus. Benjamin (1992) described the new genus *Cupulomyces* for a species formerly included in *Acompsomyces*, *Cupulomyces lasiochili* (Thaxt.) R.K.Benj.

The five species remaining in *Acompsomyces* parasitize beetles of the families Cryptophagidae and Lathridiidae (Coleoptera Cucujoidea), *A. corticariae*, *A. brunneolus* and *A. parvus* occurring on *Corticaria* (Lathridiidae). In the Cryptophagidae, *Atomaria* is host to *A. atomariae* and *A. pauperculus*, with *Anchicera* being an additional host for *A. pauperculus*. With this work, the host range of *Acompsomyces* is increased with some new genera (*Ootypus* in the Cryptophagidae, and *Melanophthalma* and *Corticarina* in the Lathridiidae).

The geographical distribution of *Acompsomyces* species is not yet known because until now only *Acompsomyces atomariae* was found beyond the American continents. Like many other laboulbeniaceous species, as suggested in this study, many species of the genus might have a worldwide distribution.

In this study one new species is described, and some new information for the remaining species is given. Two comparative tables for all the known species of the genus are here presented. These may be used as synoptic keys to identify the different species of *Acompsomyces*. Except for the new taxon, in the description of species below, only the important diagnostic characteristics are reported (for additional details, see Benjamin, 1989). Specific observations on perithecial apex structure are discussed, in order to clarify the number, position and interrelationships of its cells.

## MATERIALS AND METHODS

The *Acompsomyces* species included in this work were obtained from insects captured in the field directly by the author or from dry insects preserved in the entomological collection of Zoological Museum of Barcelona (MZB, see below). The beetles parasitized with *Acompsomyces* have similar habitats under wet vegetable debris. I have found these beetles under wet mown straw in summertime. Nevertheless, species of *Acompsomyces* appear infrequently in Spain. I have collected hundreds of beetles of the above mentioned genera and less than 5% were parasitized.

All the specimens studied were placed in BCB-Mycotheca (herbarium at the institutional address of the author). The methods used are basically the same reported in other papers of the author (Santamaria, 1991, 1992). Additional observations on perithecial apex structure and photomicrographs were made with a Leitz DMRB microscope equipped with differential interference contrast optics.

## DESCRIPTIONS OF SPECIES

***Acompsomyces brunneolus*** Thaxter (Figs. 1-3, 22-26)

> SPECIMENS EXAMINED.- SPAIN. BARCELONA: On the elytra and legs of *Melanophthalma distinguenda* (Comolli) (Coleoptera Lathridiidae), Gualba, 31TDG52, 30-VII-90, leg. S.Santamaria, BCB-Mycotheca SS·972. On lower side of the entire body of *M. distinguenda*, Gualba, 31TDG52, 10-VIII-90, leg. S.Santamaria, BCB-Mycotheca SS·988. On the elytra of *Corticarina fulvipes* (Comolli) (Coleoptera Lathridiidae), Sant Miquel del Fai, 31TDG31, without collecting date, collection of MZB ("Museu de Zoologia de Barcelona"), BCB-Mycotheca SS·1177.

Twelve mature and three immature thalli of this species have been studied. The measurements of Iberian fungi are: total length to tip of perithecium 87-112 $\mu$m; perithecium 67-86 x 33-39 $\mu$m; length of cell VI 9-17 $\mu$m; length of appendage basal cell 9-12 $\mu$m; primary appendage 33-37 $\mu$m; length of cell II 5-8 $\mu$m; spinous process (representing original spore apex) 3-5 $\mu$m; length of cell III 7-12 $\mu$m.

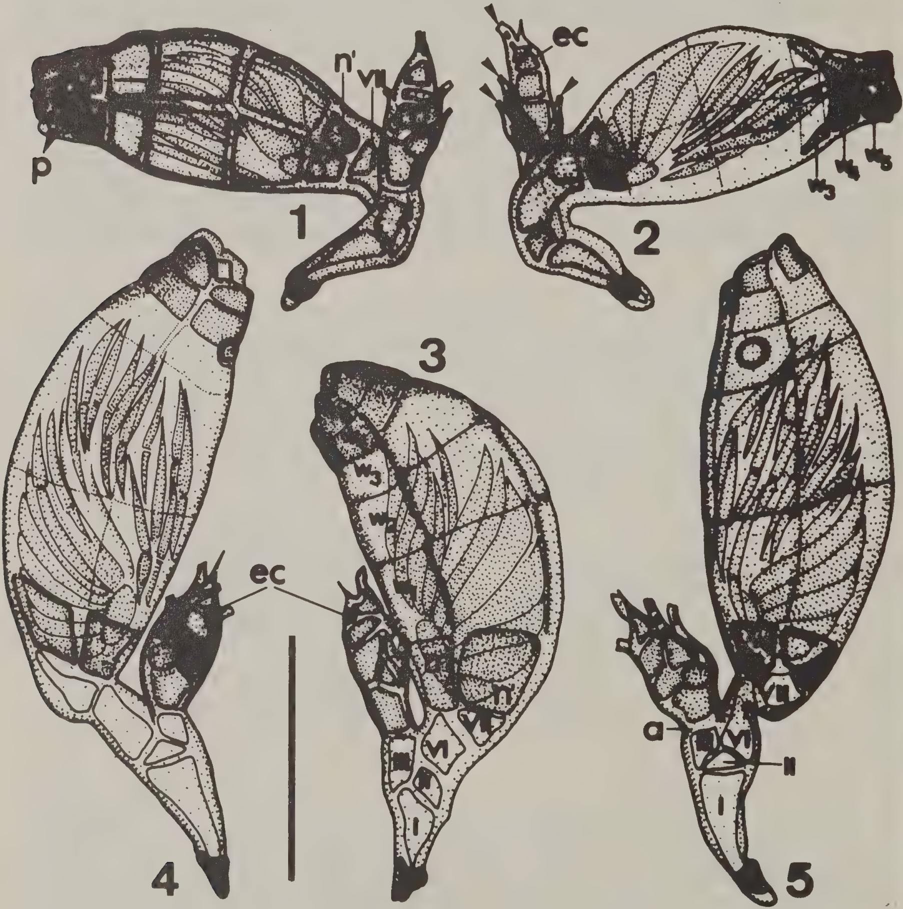
DIAGNOSTIC CHARACTERISTICS.- RECEPTACLE: Basal cell (I) separated from the subbasal cell (II) by an oblique cross-wall. Terminal cell (III) united internally with cell II, and longer than II. Cell III in contact with the apex of cell I by means of a diagonal wall. APPENDAGE: Distal cell forming a single antheridium and externally a small sterile cell. Spinous process prominent. Intermediate cross walls transverse or diagonal. PERITHECIUM: Distal margins externally rounded and strongly protruding. Apex truncate and asymmetric, surrounding a small conical ostiole.

The specimens from Spain illustrated in figs. 1, 2 and 23 to 26 show a symmetrical apex because of the lateral orientation of the thalli. Two vertical wall cell rows have protruding distal cells that extend farther apically than the comparable cells of the other two vertical wall cell rows. The perithecial apex appears asymmetrical when viewed from the side in which the longer and shorter wall cell rows are both visible (figs. 3 and 22). As in many other species of Laboulbeniales, the position of fungi on different parts of the host may affect thallus size and often also the shape of some cells. Thus, the highly curved thalli in figs. 1 and 2 grew on the lower surface of the body of the host.

The fungus illustrated in fig. 3 has diagonal appendage cross-walls as is typical in *A. corticariae*, but cells II and III are side-by-side as is typical in *A. brunneolus*. This discrepancy suggested that the direction of cross-walls may be of little significance. The perithecial apices of *A. brunneolus* (figs. 22 to 26) and *A. corticariae* (fig. 21) indicate a close relationship, despite the difference in II cells. Benjamin (1989) used the cross-wall to differentiate these species in his key. I have included the variation in the diagnostic characteristics mentioned above and also in table 1. With this alteration the only useful characteristics to separate these taxa are those of the receptacle structure (see tables 1 and 2). *Acompsomyces corticariae* and *A. brunneolus* may be found on the same host species.

The Iberian hosts belong to two genera which are new for this species: *Melanophthalma* and *Corticarina*. *Melanophthalma* is host of *Benjaminella* *melanophthalmae* [Thaxt.] I.I.Tav. from Argentina, and *Corticarina* is closely related to the typical genus *Corticaria*.

*Acompsomyces brunneolus* was previously reported from U.S.A. (Thaxter, 1905) and Argentina (Spegazzini, 1917), but Benjamin (1989) believed Spegazzini's material to be *A. corticariae*.

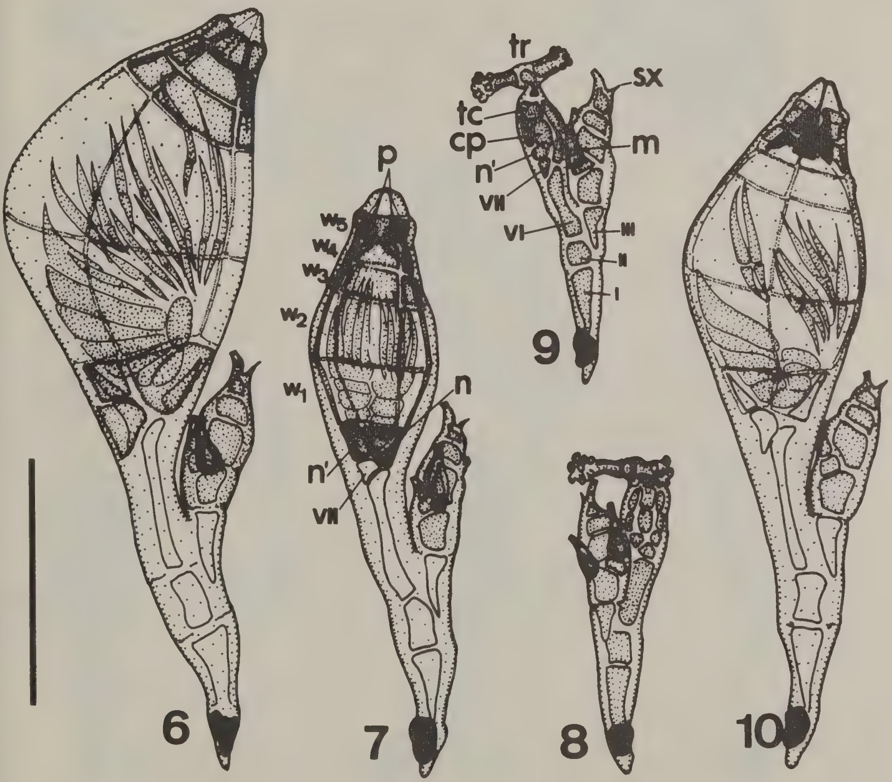


**Figs. 1-3**. *Acompsomyces brunneolus* (Figs. 1-2: BCB-SS·988; Fig. 3: BCB-SS·1177). Figs. 1-2. Strongly curved specimens from the lower surface of the host body of *Melanophthalma distinguenda*. Fig. 3. Straight specimen from the elytra of *Corticarina fulvipes*. **Figs. 4-5**. *Acompsomyces corticariae* (BCB-SS·1433). (Abbreviations used: I, basal cell of receptacle; II, subbasal cell of receptacle; III, third cell of receptacle; VI, stalk cell of perithecium; VII, secondary stalk cell of perithecium; a, original septum of spore; ec, small cell separated from terminal antheridiiferous cell; m, basal cell of perithecium formed from cell VI; n', second basal cell formed from cell VII; p, inner wall cells; $w^{1-5}$, five tiers of outer wall cells; "arrows", antheridia.) (Scale bar = 50 $\mu$m.)

### *Acompsomyces corticariae* Thaxter (Figs. 4-5, 21)

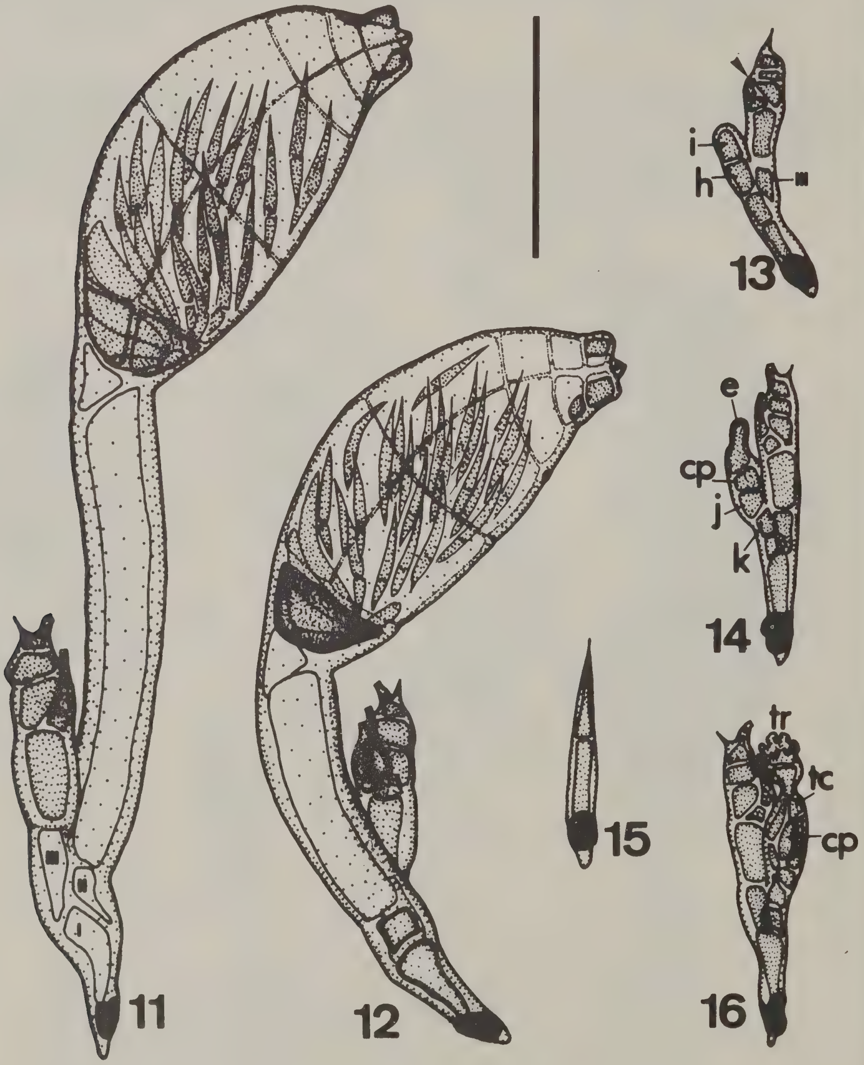
SPECIMENS EXAMINED.- SPAIN. GIRONA (GERONA): On the elytra of *Melanophthalma distinguenda* (Comolli) (Coleoptera Lathridiidae), Meda gran, Medes Islands, 31TEG15, 2-V-61, collection of MZB ("Museu de Zoologia de Barcelona"), BCB-Mycotheca SS·1433.

Six mature specimens of this species have been studied. The measurements are: total length to tip of perithecium 137-140 μm; perithecium 99-105 x 39-41 μm; length of cell VI 15-17 μm; length of appendage basal cell 8-9 μm; primary appendage 35 μm; length of cell II 3-4 μm; spinous process on appendage 7-9 μm; length of cell III 6-9 μm.



**Figs. 6-10**. *Acompsomyces ootypi* (Figs. 8 and 9: BCB-SS·985; Figs. 6 and 10: BCB-SS·789b; Fig. 7: BCB-SS·789c). Figs. 8 and 9. Immature specimens. (Abbreviations used: cp, carpogonial cell; n, basal cell of perithecium formed from cell VII; sx, spore apex -spinous process-; tc, trichophoric cell; tr, trichogyne. Remaining abbreviations as in the previous plate.) (Scale bar = 50 μm.)

DIAGNOSTIC CHARACTERISTICS.- RECEPTACLE: Basal cell (I) separated from the subbasal cell (II) by a transverse cross-wall. Terminal cell (III) not in contact with the basal cell (I). Cells II and III separated by an oblique wall. Cell II triangular in optical



**Figs. 11-16**. *Acompsomyces pauperculus* (BCB-SS·1380). Figs. 13, 14 and 16. Three consecutive stages of development. Fig. 15. Sporeling. (Abbreviations used: e, young trichogyne; h and i, respectively, lower and upper cells formed by division of perithecial initial cell; j, becomes cell VII; k, becomes cell VI. Remaining abbreviations as in the previous plates.) (Scale bar = 50 $\mu$m.)

section. APPENDAGE: Distal cell forming a single antheridium and externally a sterile small cell. Spinous process prominent and long. Intermediate cross-walls diagonal. PERITHECIUM: Distal margins externally rounded and strongly protruding. Apex truncate and asymmetric, surrounding the small, conical ostiole.

The specimens seen are fully in accordance with the typical characteristics described by Benjamin (1989). Found on *Melanophthalma* which is a new host for this species. Previously reported from U.S.A. (Thaxter, 1901), Argentina and Chile (Benjamin, 1989).

***Acompsomyces ootypi*** Santamaria sp. nov. (Figs. 6-10, 17-20, 27-29)

Thallus hyalinus vel lutescens. Saeptum I-II transversale. Cellula III a cellula I separata, summum in media superiore parte cellulae II adnata. Appendix quattuor cellulis superpositis confecta, quarum basalis sustinens 2-3 antheridia; cellula distalis antheridium est. Perithecium latum, ventrali margine valde arcuato. Apicalis series parietalium cellularum protuberans.

Tota longitudo usque ad perithecii apicem: 122-162 μm. Tota longitudo appendicum: 25-32 μm. Perithecia: 65-83 x 30-50 μm.

HOLOTYPUS: Super Ootypo globoso Waltl (Coleoptera Cryptophagidae Ephistemini), in Hispania septentrionali, BCB-Mycotheca SS·789b.

Thallus hyaline to pale yellow, 122-162 μm long. Cell II separated from cell I by a transverse cross wall. Cell II rectangular in optical section (7-12 μm height). Cell III subtriangular in optical section (8-15 μm height), not in contact with cell I, but united with the inner upper margin of cell II, the lower part sometimes reaching down to the middle of cell II. Appendage long (25-32 μm), with the margins constricted at septa, consisting of four superposed cells, the basal cell (7-9 μm height) supporting usually three antheridia; the medial antheridium has a supporting sterile cell. Distal cell of appendage forming a single antheridium, with an inwardly directed, curved neck and bearing on its upper surface a very short and slender (1-3 μm long) spinous process. Basal and subbasal cells of appendage similar in height, both together forming ca. 2/3 the total length of appendage. Cell VI long (26-31 μm). Perithecium almost globose and broad (65-83 x 30-50 μm), with the ventral margin very convex and with the tip inwardly directed. The three apical tiers of perithecial wall cells are very short in relation to the lower two tiers. The upper outer wall cells are distally enlarged and rounded externally. Perithecial tip prominent, conical and symmetric.

ETYMOLOGY. From *Ootypus*, the host genus name.

**HOLOTYPE.** SPAIN. GIRONA (GERONA): Over the entire body of *Ootypus globosus* Waltl (Coleoptera Cryptophagidae Ephistemini), Riells i Viabrea, 31TDG62, 10-IV-88, leg. S.Santamaria, BCB-Mycotheca SS·789b.

**ISOTYPES.** *Ibidem*, BCB-Mycotheca SS·789a, SS·789c.

**PARATYPES.** SPAIN. BARCELONA: Over the entire body of *Ootypus globosus* Waltl, Gualba, 6-VIII-90, leg. S.Santamaria, BCB-Mycotheca SS·980. *Ibidem*, 10-VIII-90, leg. S.Santamaria, BCB-Mycotheca SS·985.

I found 26 mature and 12 immature specimens of this species. Some material included in this diagnosis was published as *Acompsomyces atomariae* Thaxt. in Santamaria (1989) and the host as *Ephistemus globulus* (Payk.). In that publication several critical characteristics were mentioned that might be considered when describing a new species to which more collections might later be added so that the value of the characters could be more satisfactorily assessed (Santamaria, 1989, pages 239-240). *Acompsomyces ootypi* is closely related to *A. atomariae* and *A. pauperculus*, but may be separated from them by the disposition and shape of the cells in the primary receptacle. Likewise, the shape of the perithecium and its apex separate *A. ootypi* (and also *A. atomariae*) from *A. pauperculus*.

The ostiolar tip of this species shows no cellular structure (figs. 6-7, 10 and 27 to 29), appearing hyaline with cotton blue staining. Some early stages of development seen (fig. 17) do not clarify satisfactorily this enigma. In the photographed immature thallus (fig. 17) the fourth wall cell is beginning to divide into the fourth and fifth tiers. The ostiolar tip above these cells does not show clear cytoplasmic elements and no cross-wall is formed between the fifth tiers and the ostiolar tip (figs. 27-29). The structure of the perithecial tip appears to be very similar to that of *A. atomariae* (Benjamin, 1989).

The host, *Ootypus globosus*, may be found in the same habitats as the other hosts parasitized by *Acompsomyces*. This host may be confused with *Ephistemus*, requiring identification by a specialist.

### *Acompsomyces pauperculus* Thaxter (Figs. 11-16)

SPECIMENS EXAMINED.- SPAIN. BARCELONA: On the legs of *Anchicera pallidipennis* Holdh. (Coleoptera Cryptophagidae), Bonanova, 31T DF38, XI-16, collection of MZB ("Museu de Zoologia de Barcelona"), BCB-Mycotheca SS·1226. On the elytra margins of *Atomaria* sp. (Coleoptera Cryptophagidae), Valldoreix, 31TDF29, 28-VIII-80, leg. Español, collection of MZB ("Museu de Zoologia de Barcelona"), BCB-Mycotheca SS·1380.

I have studied 9 mature and 8 immature specimens of this species. The measurements of Iberian fungi are: total length to tip of perithecium 143-227 μm; perithecium 93-105 x 41-47 μm; length of cell VI 53-100 μm; length of appendage basal cell 12-19 μm; primary appendage 30-43 μm; length of cell II 3-10 μm; spinous process of appendage 3-5 μm; length of cell III 9-20 μm.

DIAGNOSTIC CHARACTERISTICS.- RECEPTACLE: Basal cell (I) separated from the subbasal cell (II) by a strongly oblique cross-wall. Terminal cell (III) united internally with cell II by a longitudinal cross-wall. Cell III in contact with the apex of cell I.

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**Figs. 17-20**. *Acompsomyces ootypi* (Figs. 17 and 19: BCB-SS·789b; Figs. 18 and 20: BCB-SS·789c). Fig. 17. Immature specimen with four tiers of perithecial wall cells ($w_1$-$w_3$) and in which the fourth apical tier (o) is beginning to divide (arrow) into the fourth and the fifth tiers. (Scale bar fig. 17 = 25 μm; Scale bar fig. 18 = 50 μm, is the same for the figs. 19 and 20.) (All the specimens figured were stained with cotton blue.)

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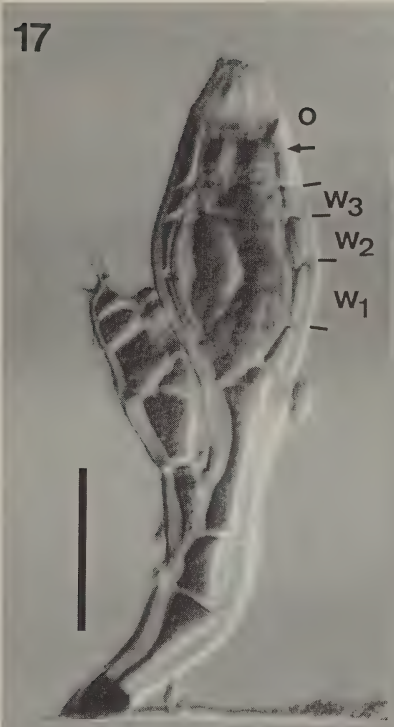

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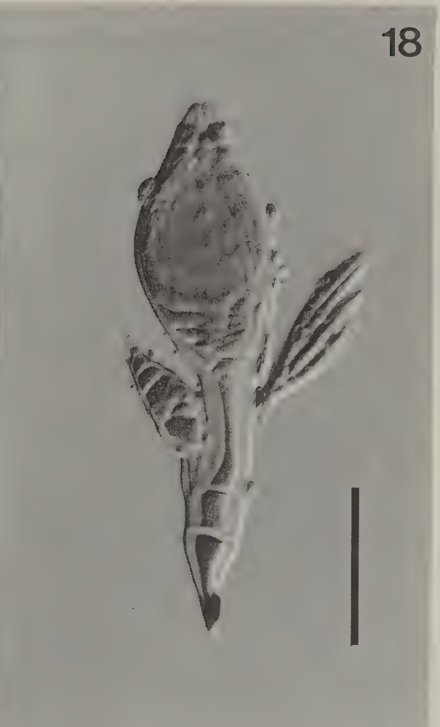

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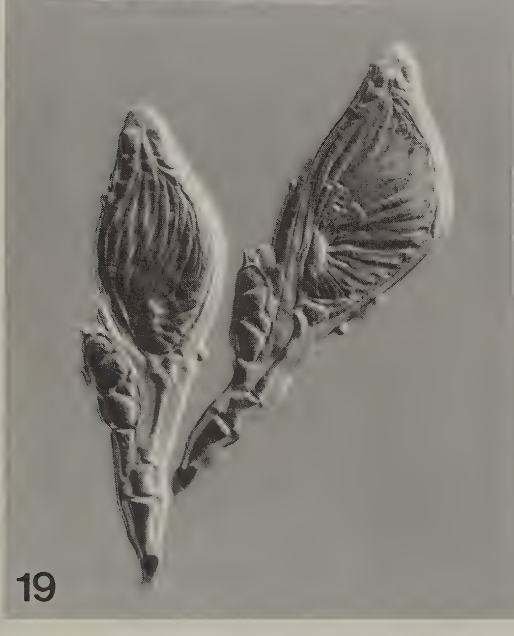

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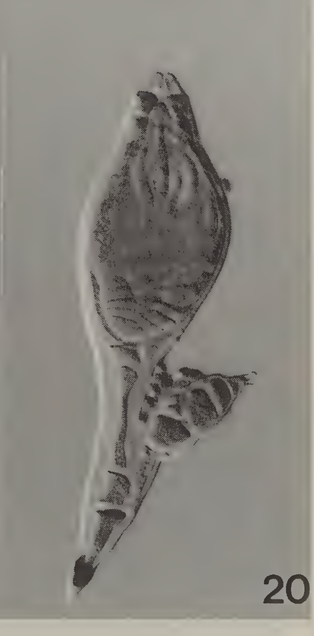

APPENDAGE: One to three antheridia on the basal cell. Distal cell forming a single antheridium. Spinous process prominent and short. Intermediate cross walls transverse to slightly oblique. PERITHECIUM: Distal margins externally protruding below the conical tip.

This species is very similar to *Acompsomyces atomariae* Thaxt. but may be distinguished from it by the difference in size of the basal cell of the appendage and the conformation of the perithecial tip. The Iberian specimens illustrated have a very long cell VI and a curved perithecium; these peculiar characteristics are probably due to the growing position on the host, the lateral margins of elytra. Despite these differences, they have the typical diagnostic characteristics.

Only known previously from U.S.A. (Thaxter, 1902).

## DISCUSSION

The six known species of the genus *Acompsomyces* may be separated if we study accurately the diagnostic characteristics, mainly based on the appendage and receptacle, the number, shape and disposition of the cells, and, sometimes, the comparative size. Other additional characters are those of the perithecium, chiefly of the apex.

Benjamin (1989) has made some observations of the perithecial apex structure, but the relationships between the bulges and the conical tip were still unclear. Benjamin assumes that there are five tiers of perithecial outer wall cells in all *Acompsomyces* species and no cross-walls are formed between the bulges and the conical tip. I have made some specific observations of the apex structure of the species included in this work using differential interference contrast optics.

According to Tavares (*in litteris*) the ostiolar opening should be controlled by some cytoplasmic area. The ostiolar cone appears faintly structured in all the observations. In *A. brunneolus* (figs. 22 to 26) the bulges of the perithecial apex extend somewhat beyond the ostiole proper which is conical and sharply pointed. In the specimens studied the ostiolar area is connected with the bulging area without any separating cross-wall (fig. 26). The inner wall cells are very evident in their two apical tiers (fig. 26). Under the ostiolar channel is clearly visible a small cavity of unknown function (fig. 26).

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**Fig. 21**. *Acompsomyces corticariae* (BCB-SS·1433). Perithecial apex. Three rows of outer wall cells are seen in their three apical tiers. The ostiole is marked by an arrow. **Figs. 22-26**. *Acompsomyces brunneolus* (Fig. 22: BCB-SS·972; Figs. 23-26: BCB-SS·988). Perithecial apices at different focusing levels. In figs. 24 and 25, thin channels of cytoplasm are seen in the middle of ostiolar lips (arrows). In fig. 26 the two apical tiers of inner wall cells are seen (p) and under the ostiole channel is observed one round cavity (arrow). **Figs. 27-29**. *Acompsomyces ootypi* (BCB-SS·789a). Perithecial apices. Figs. 27 and 28 are two different focusing levels of the same specimen. In fig. 27 the focus is on the outer surface to emphasize the outer wall cells and compare them with the faint ostiolar tip. (Abbreviations as in the previous plates.) (Scale bar = 25 μm, for all the figures.) (All the specimens were stained with cotton blue.)

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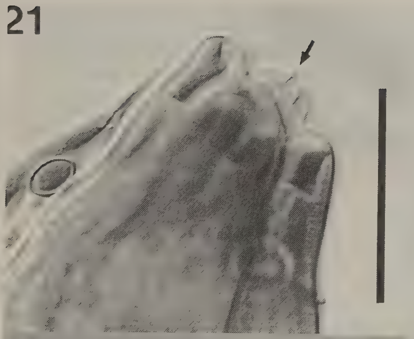

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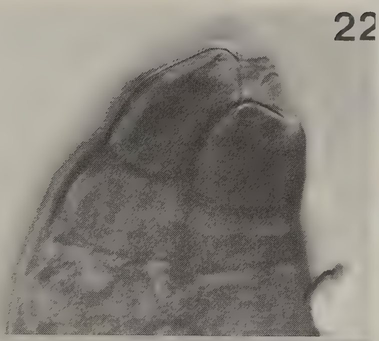

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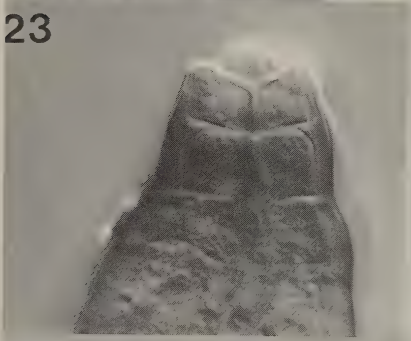

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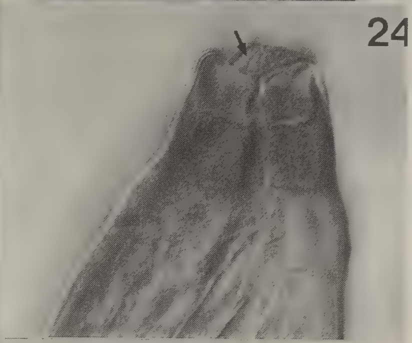

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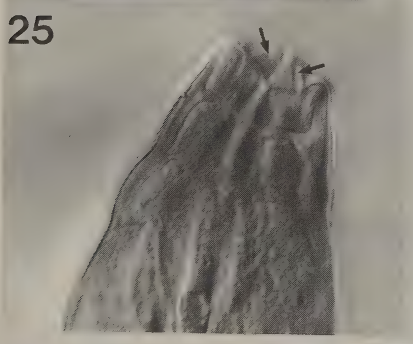

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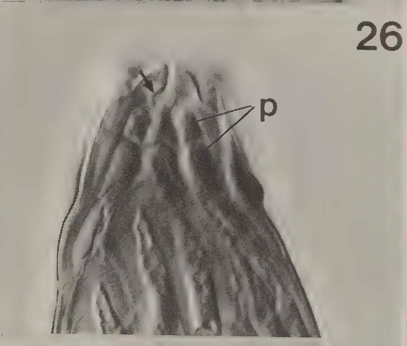

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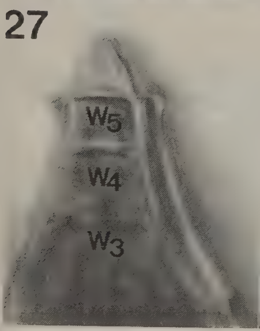

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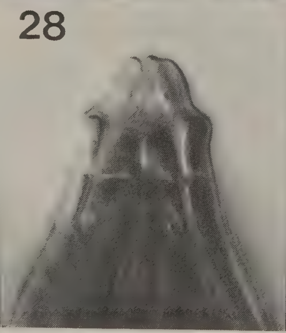

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**Table 1.** Comparison of six species of *Acompsomyces*, in thallus features and ecology.

| | *A. atomariae* | *A. brunneolus* | *A. corticariae* | *A. ootypi* | *A. parvus* | *A. pauperculus* |
|---|---|---|---|---|---|---|
| Septum I-II | Oblique | Oblique | Transverse | Transverse | Oblique | Oblique |
| Septum II-III | Vertical | Vertical to slightly oblique | Oblique | Vertical | Vertical | Vertical |
| Shape of cell II in optical section | Trapezoidal | Trapezoidal | Triangular | Rectangular | Subtriangular | Trapezoidal |
| Cell III united with I ? | Yes | Yes | No | No | Yes | Yes |
| Number of superposed appendage cells | 4 | 4 | 4 | 4 | 5 | 4 |
| External sterile cell separated from terminal appendage cell | No | Yes | Yes | No | Yes | No |
| Cross walls of intermediate appendage cells | Oblique | Transverse to oblique | Oblique | Transverse to slightly oblique | Transverse | Transverse to oblique |
| Perithecial tip and apical outer wall tiers | Symmetric. Slightly protruding | Asymmetric. Strongly protruding | Asymmetric. Strongly protruding | Symmetric. Slightly protruding | Asymmetric. Strongly protruding | Symmetric. Strongly protruding |
| Habitat & Geographic distribution | *Atomaria*<br>*Anchicera*<br>U.S.A.,<br>POLAND | *Corticaria*<br>*Melanophthalma*<br>*Corticarina*<br>U.S.A.,<br>SPAIN | *Corticaria*<br>*Melanophthalma*<br>U.S.A.,<br>ARGENTINA,<br>CHILE,<br>SPAIN | *Ootypus*<br>SPAIN | *Corticaria*<br>U.S.A. | *Atomaria*<br>*Anchicera*<br>U.S.A.<br>SPAIN |

**Table 2.** Comparison of six species of *Acompsomyces*, in thallus measurements (in μm).

| | *A. atomariae* | *A. brunneolus* | *A. corticariae* | *A. ootypi* | *A. parvus* | *A. pauperculus* |
|---|---|---|---|---|---|---|
| Total length | 120-180(*) | 95-135(*)<br>87-112 | 110-150(*)<br>137-140 | 122-162 | 70-80(*) | 113-143(*)<br>143-227 |
| Perithecium | 62-95 x 24-41(*) | 63-85 x 24-36(*)<br>67-86 x 33-39 | 69-98 x 27-40(*)<br>99-105 x 39-41 | 65-83 x 30-50 | 42-52 x 17-21(*) | 65-90 x 24-40(*)<br>93-105 x 42-47 |
| Length of cell VI | 22-40(*) | 12-16(*)<br>9-17 | 12-21(*)<br>15-17 | 26-31 | 6-9(*) | 15-24(*)<br>53-100 |
| Length of appendage basal cell | 10-15(*) | 8-13(*)<br>9-12 | 9-13(*)<br>8-9 | 7-9 | 8-10(*) | 14-20(*)<br>12-19 |
| Total length of appendage | 32-43(*) | 34-40(*)<br>33-37 | 30-40(*)<br>35 | 25-32 | 25-32(*) | 33-44(*)<br>30-43 |
| Length of cell II | 7-13(*) | 4-6(*)<br>5-8 | 4-6(*)<br>3-4 | 7-12 | 3-5(*) | 5-9(*)<br>3-10 |
| Length of spinous process | 3-5 | 7-8(*)<br>3-5 | 7-10(*)<br>7-9 | 1-3 | 4-5(*) | 3-5(*)<br>3-5 |
| Length of cell III | 11-19(*) | 8-11(*)<br>7-12 | 5-11(*)<br>6-9 | 8-15 | 9-10(*) | 13-21(*)<br>9-20 |

Some observations show a middle line at the center of each side of the ostiolar tips (figs. 24 and 25); these lines may be interpreted as very thin channels of cytoplasm, as happens in *Cupulomyces* (Benjamin, 1992). In *A. corticariae* the perithecial apex is very similar to that of *A. brunneolus* (fig. 21), but it is more asymmetrical because the ventral bulges are more prominent. In *A. ootypi* the ostiolar tip is large and apically obtuse; the bulges are less protruding than in *A. corticariae* and in *A. brunneolus* (figs. 27 to 29).

With the material studied some conclusions concerning the perithecial apex may be achieved: there are five tiers of perithecial outer wall cells, the fifth apical wall cell ($w_5$) appears undivided; the ostiole opening may be controlled by a narrowing of the cytoplasm (seen in *A. brunneolus*) and therefore the perithecial apex of *Acompsomyces* may be compared to that of *Cupulomyces*, the inner apical wall cells of the perithecium might participate in the control of the ostiole opening in species such as *A. ootypi* where no clear cytoplasmic channel is seen in the ostiolar tip.

The species of this genus may be placed in two groups; each one, besides the morphological similarities, parasitizes a different family of beetles. *Acompsomyces atomariae, A. ootypi* and *A. pauperculus*, on Cryptophagidae, have an appendage with four superposed cells, the distal one forming a single antheridium, and the perithecial tip is symmetric. *Acompsomyces brunneolus, A. corticariae* and *A. parvus*, on Lathridiidae, have an appendage with four or five superposed cells, the distal one forming an antheridium and one sterile small cell, and the perithecial tip is asymmetric with the outer wall cells externally protruding below the apex. However, the construction of the perithecial apex is similar in *A.pauperculus, A. brunneolus*, *A. corticariae* and *A. parvus*.

Tables 1 and 2 summarize the information about the six species of this genus. These tables may be useful for identifying these species. The characteristics included in the tables have been obtained from personal observations, and from Benjamin (1989); *Acompsomyces atomariae* and *A. parvus* were not seen by the author. In the measurements table (table 2), those marked with (*) are from the literature.

The author wishes to express his gratitude to O.Escolà (curator of MZB) for supplying parasitized insects, to J.C. Otero for the identification of some of the insects mentioned in this paper, to J.Fortes and J.Carbonell for the Latin diagnoses, and to I.Tavares, R.K. Benjamin and W.Rossi for critical reading of the manuscript.

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# GLOMALES OF TAIWAN:
# IV. A MONOGRAPH OF SCLEROCYSTIS (GLOMACEAE)

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KEY WORDS: *Sclerocystis, S. sinuosa, S. coremioides, S. clavispora, S. taiwanensis, S. liquidambaris, S. rubiformis,* taxonomy.

## ABSTRACT

Six species of *Sclerocystis* (*S. clavispora*, *S. coremioides*, *S. liquidambaris*, *S. rubiformis*, *S. sinuosa*, and *S. taiwanensis*) from Taiwan are described and illustrated, and a key to species is provided. Spores of these species were assigned to one of three size-classes based on an area index calculated by multiplying length x width: 1000-3000 $\mu m^2$, 6000-8000 $\mu m^2$, and intermediate sized spores. *Sclerocystis clavispora* and *S. liquidambaris* formed large and small spores, sometimes in the same sporocarp. *Sclerocystis rubiformis* and *S. taiwanensis* mostly produced smaller spores; however, the spore size of *S. sinuosa* and *S. coremioides* were mainly intermediate between smaller and larger spore groups.

## INTRODUCTION

The genus *Sclerocystis* was recently emended on the basis of comparative studies of spore ontogeny and sporocarp morphology (Wu, 1993). Sufficient evidence resulted from that study to retain *Sclerocystis* sensu Gerdemann and Trappe (1974) as distinct from *Glomus*. The suggestion by Almeida and Schenck (1990) to synomize all but one species of *Sclerocystis* with *Glomus* was not accepted. The emended description reads, "**sporocarps globose or subglobose or hemispherical, enclosed by a peridium or naked, with a multihyphal stipe or monohyphal stalks; chlamydospores arranged side by side in a single layer, radiating out from a central plexus of hyphae; central plexus composed of a broad, stellate thick-walled cell or interwoven hyphae; development of chlamydospores within sporocarps synchronous or asynchronous; sidebranches frequently produced from the base of chlamydospores, becoming spores or intersporal hyphae**".

During an investigation of arbuscular mycorrhizal fungi in Taiwan, numerous sporocarps of *Sclerocystis* were isolated by a wet-sieving and decanting method (Gerdemann and Nicolson, 1963). The sporocarps were further purified by sucrose centrifugation (Jenkins, 1964). Sporocarps and spores were mounted in Hoyer's medium and made into semipermanent slides. Some sporocarps were also preserved in FAA fixative. Specimens are deposited in the Soil Microbiology Lab, Agricultural Chemistry Department, Taiwan Agricultural Research Institute, Wu-feng, Taichung, Taiwan, R.O.C. and Mycological Herbarium, Department of Plant Pathology, University of Florida, Gainesville, Florida, U. S. A.

In this study, some species of *Sclerocystis* produce spores in two different sizes (large and small). Since spores of *Sclerocystis* mostly are elliposoid to clavate, their outer figures in optical section side view are

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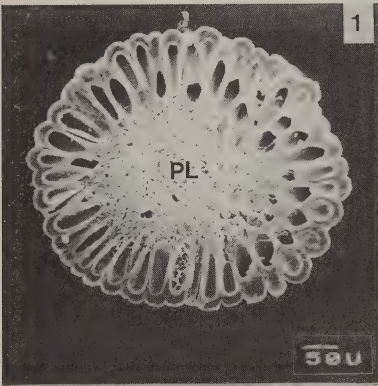
Figures 1-6. Micrographs of sporocarps of *Sclerocystis* spp. Fig. 1. & 2. Scanning electron micrographs of *S. clavispora*. Fig. 1. Cross section of a sporocarp of *S. clavispora* showing chlamydospores radially arranged on plexus (PL). Fig. 2. Surface view of sporocarp of *S. clavispora* showing exposed chlamydospores. Fig. 3. Sporocarps of *S. coremioides* formed in chain, scale=70 µm. Fig. 4. Part of a sporocarp of *S. clavispora* showing chlamydospores variable in size and some young spores in the vesicular stage (S), scale=35 µm. Fig. 5. Part of a sporocarp of *S. liquidambaris* showing chlamydospores embedded in "paraphysis-like" structures (P), scale=35 µm. Fig. 6. Young sporocarps of *S. rubiformis* in fan shape and connected with a hyphal stalk (T).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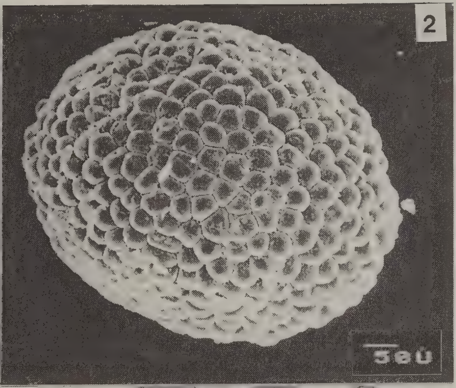
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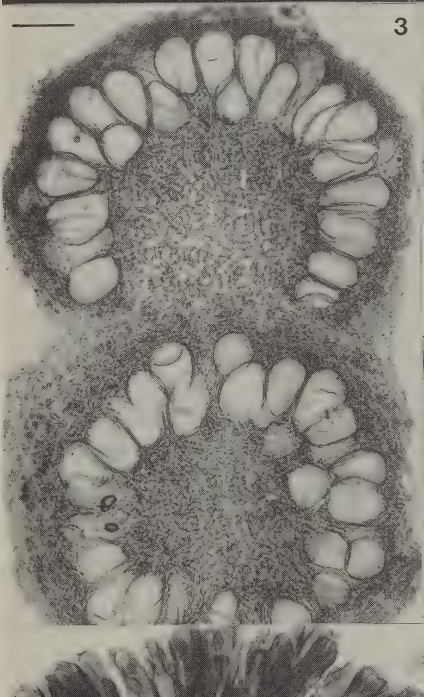
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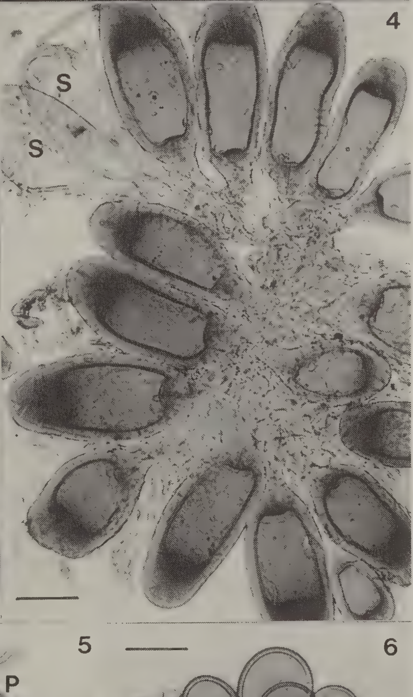
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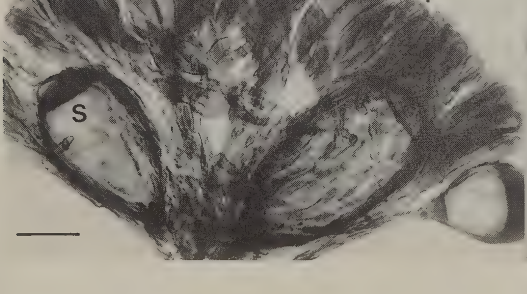
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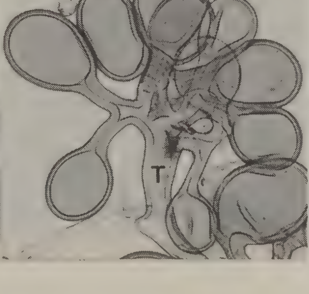
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measured as rectangles. Therefore, spore size is determined by an area index calculated by multiplying length and width. The distribution curve of spore size in each species is depicted by area indices and their frequency.

## SPECIES DESCRIPTIONS

**1. *Sclerocystis clavispora*** Trappe, Mycotaxon 6:359-361, 1977.
(Figures 1, 2, 4, 13)
=*Sclerocystis microcarpus* Iqbal & Bushra, Trans. Mycol. Soc. Japan 21:58-59, 1980.

Sporocarps globose, subglobose, brown to blackish brown, 300-600 x 400-700 µm, without peridium, usually with one to four monohyphal stalks; chlamydospores brown to dark brown, radially arranged on a central plexus, developed synchronous, or asynchronous, clavate to subcylindric, 22.5-75 x 47.5-157.5 µm; spore wall usually thickened at apex, up to 40 µm.

COLLECTIONS EXAMINED: **1**. TAIWAN: Chi-tou, from rhizosphere of *Chimonobambusa quadrangularis* (Fenzi) Markino, Wu-850821; **2**. TAIWAN: Chi-tou, from the rhizosphere of *Erechthites valerianifolia* (Walf.) DC., Wu-8508201; **3**. TAIWAN: Chi-tou, from the rhizosphere of *Gingo biloba* L., Wu-8508202; **4**. TAIWAN: Chi-tou, from the rhizosphere of *Colocasia formosanum* Hayata, Wu-8607151; **5**. TAIWAN: Kenting, from the rhizosphere of *Colocasia formosanum*, Wu-8605171; **6**. TAIWAN: Pintong, from the rhizosphere of asparagus (*Asparagus*

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Figures 7-12. Micrographs of sporocarps of *Sclerocystis* spp. Fig. 7. Globular sporocarp of *S. rubiformis*, scale=35 µm. Fig.8. Scanning electron micrograph of *S. taiwanensis* showing chlamydospores tightly arranged on plexus. Fig. 9. Scanning electron micrograph of *S. sinuosa* showing sinuous peridium. Fig. 9A. Close up (2 x magnification) of figure 9 showing sinuous hyphae attached to chlamydospores. Fig. 10. Three chlamydospores of *S. taiwanensis* connected to plexal hypha. Note the hyaline, separable outer wall (arrow heads) of chlamydospores, scale=35 µm. Fig. 11. After peridium detached, sporocarps of *S. sinuosa* showing heterogenous types of chlamydospores, scale=70 µm. Fig. 12. Inner side of peridium of *S. sinuosa* also showing sinuous pattern.

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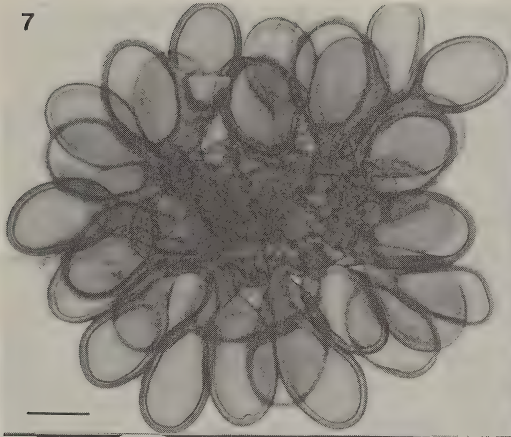

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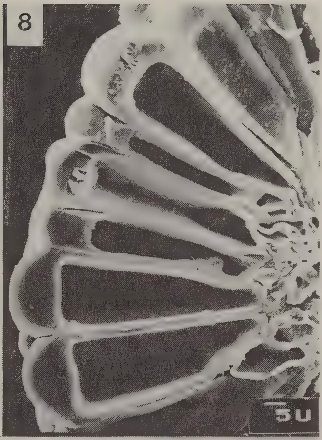

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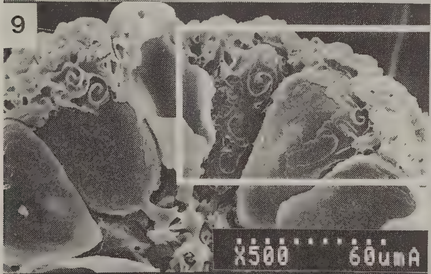
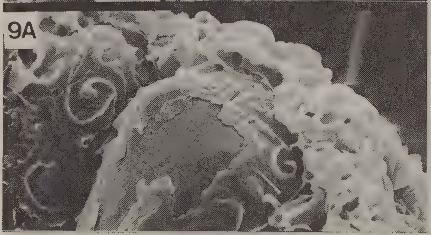
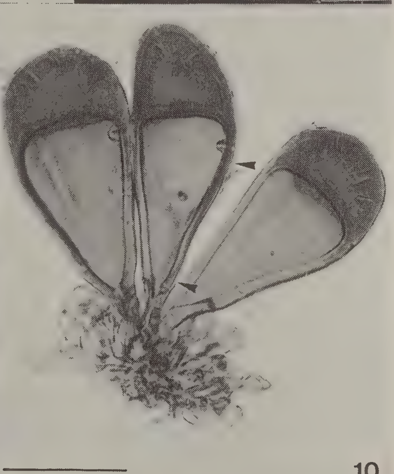


9A





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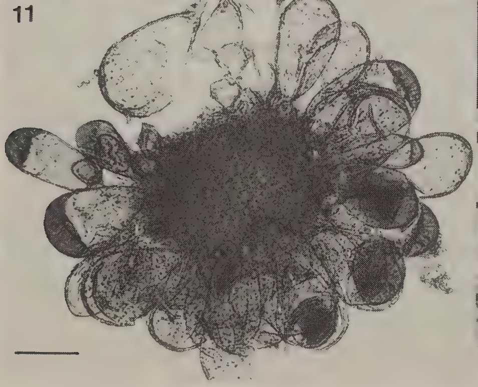

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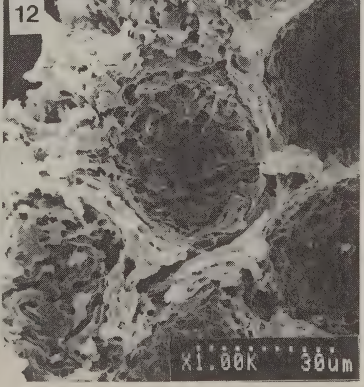

*officinalis* L.), Wu-860813; 7. TAIWAN: Wu-feng, Taichung, from the rhizosphere of rice (*Oryza sativa* L.), Wu-920717.

NOTES: *Sclerocystis clavispora* produces two distinctly different sized spores: one large (7000-8000 $\mu m^2$) and the other small (2000-3000 $\mu m^2$)(Fig. 19A). Both types of spores could be found in the same sporocarp or in different sporocarps isolated from the same rhizosphere. The sporocarps producing smaller spores formerly were identified as *S. microcarpus* (Iqbal and Bushra, 1980).

Chlamydospores sometimes developed asynchronously. In the same sporocarp, club-shaped vesicles (young spores) were often observed intermingled with mature, thick-walled spores (Fig. 4). Obviously, spore walls were thickened gradually at the apex and base. However, the factor which triggers the process of wall thickening is still unknown. It might be closely related to the production of two types of spores.

**2. *Sclerocystis coremioides*** Berk. & Bromme, J. Linn. Soc. London 14:137, 1873. (Figures 3, 14)
= *Xenomyces ochraceus* Cesati, Atti R. Accad. Sci. Fisiche e Math. Napoli 8:26, 1878.
= *Ackermannia coccogena* Pat., Bull. Soc. Mycol. France 18:183, 902.
= *Sphaerocreas coccogena* (Pat.) van Hohn, Sitzungsber. Kaiserl. Akad. Wiss. Wien Math.-Naturwiss. Kl. Abt. I. 118:401, 1909.
= *Sclerocystis coccogena* (Pat.) von Hohn., Sitzungsber. Kaiserl. Akad. Wiss. Wein Matn.-Naturwiss. Kl. Abt. I.119:399, 1910.
= *Ackermannia dussii* Pat., Bull. Soc. Mycol. France 18:180-181, 1902.
= *Spherocreas dussii* (Pat.) von Hohn., Stizungsber. Kaiserl. Akad.Wiss. Wien Math.-Naturqiss. Kl. Abt. I. 118:401, 1909.

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Figure 13. Diagram of chlamydospores of *S. calvispora*. A. Spores from smaller sporocarp. B. Spores from larger sporocarps. Note the sporophores very commonly associated with spores.

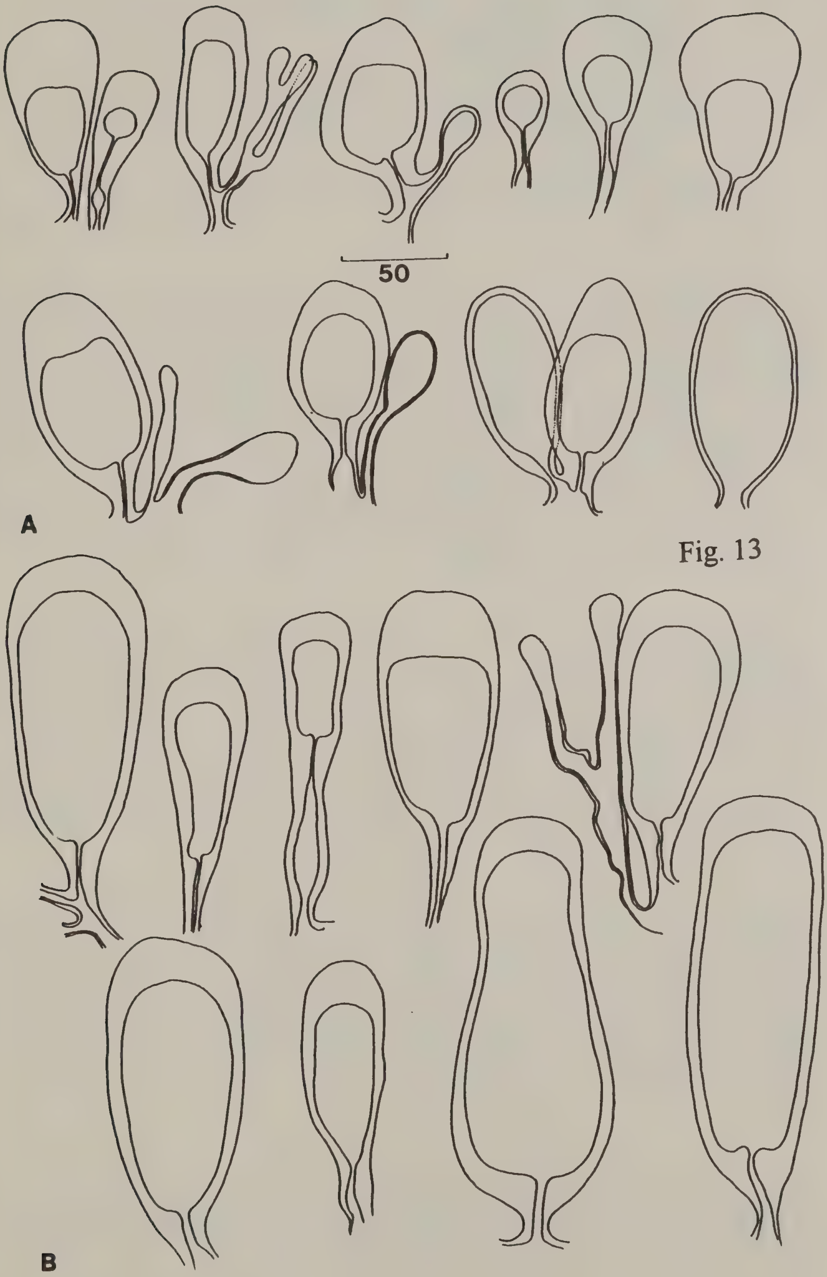

Fig. 13

= *Scelerocystis dussii* (Pat.) von Hohn., Sitzungsber. Kaiserl. Akad. Wiss. Wein Math.-Naturwiss. Kl. Abt. I.119:399, 1910.

= *Spherocreas javanicum* von Hohn., Sitzungsber. Kaisherl. Akad. Wiss. Wien Math.-Naturwiss. Kl. Abt. I. 117:1014-1015, 1908.

= *Endogne minutissima* Beeli, Bull. Soc. Roy. Bot. Belg. 56:57, 1923.

Sporocarps brown or yellow brown, 200-250 x 450-550 µm, subglobose or pulvinate, with or without multihyphal stipes, usually flattened at base; chlamydospores arranged radially in a hemispherical layer, ellipsoid, ovoid, triangular, or oblong ellipsoid to clavate, yellow brown, (35-) 45-65 (-70) x 50-80 (-90) µm; spore wall 1.5-2.5 µm and frequently thicked at base, up to 6 µm; subtending hypha long, single, occasionally two, 5-6 µm at attachment, then tapered to 7.5 µm broad; plexal hyphae broad, 6-12.5 µm; peridial hypha, thick-walled, 2.5-5 µm, sometimes with sparse septum.

**COLLECTIONS EXAMINED**: **1**. TAIWAN: Tainan, from rhizosphere of *Ageratum conyzoides* L., Wu-850725; **2**. TAIWAN: Tainan, from the rhizosphere of orange (*Citrus* sp.), Wu-8608141; **3**. TAIWAN: Taipei, from the rhizosphere of *Bignonia* sp., Wu-850810; **4**. TAIWAN: Chi-tou, from the rhizosphere of *Colocasia formosanum*, Wu-8607152; **5**. TAIWAN: Pintong, from the rhizosphere of asparagus (*Asparagus officinalis*), Wu-860813; **6**. USA: Oregon, F55365.

**NOTES**: Sporocarps collected in this study were seldom formed in rows. They exist as a thin layer, or single fruit body on soil, in agreement with the description of Jao *et al.* (1992). Sporophores produced from the bases of attached hyphae were very common; however, the septum below the spore base was not formed frequently as described by Almeida and Schenck (1990).

Figure 14. Diagram of chlamydospores of *S. coremioides*. Spores in A and B isolated from two different collection sites.

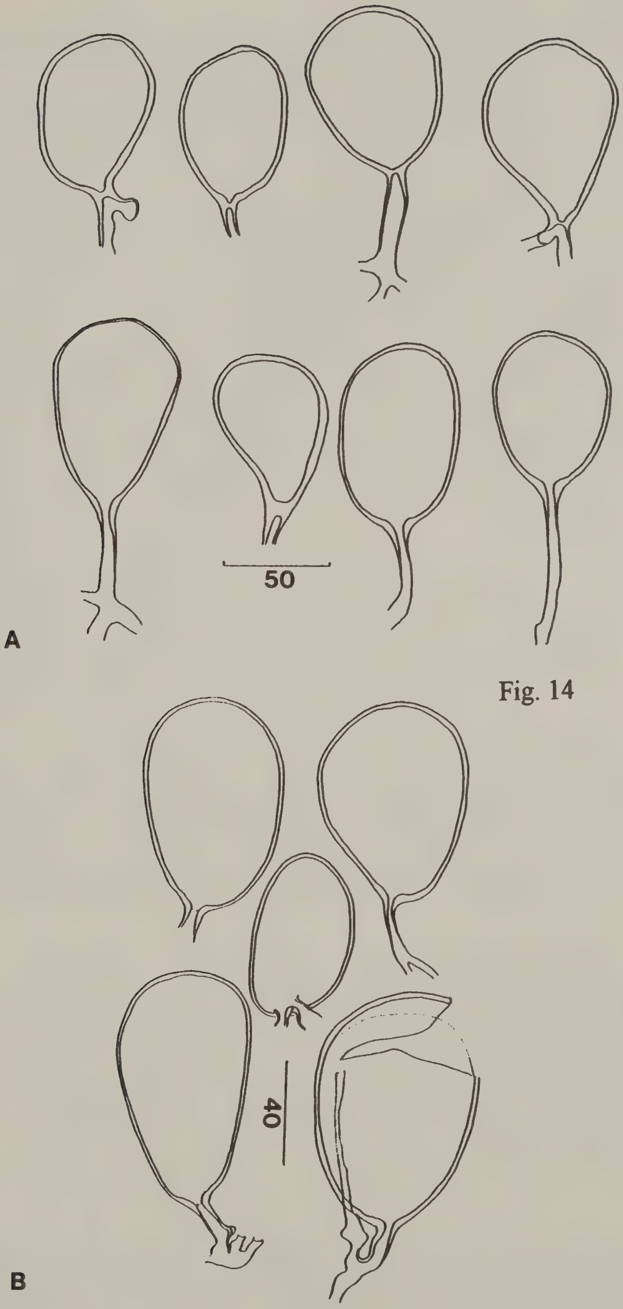

Fig. 14

**3.** ***Sclerocystis liquidambaris*** Wu & Chen, Trans. Mycol. Soc. Rep. China 2:73-83, 1987. (Figures 5, 15)
= *Sclerocystis cunninghmia* Hu, Quart. J. Chinese For. 21(2):45-72. 1988.

Sporocarps globose to subglobose, 300-600 x 370-680 µm, brown to dark brown, consisting of chlamydospores formed radially within the "paraphysis-like" structures. "Paraphysis-like" structures cylindrical, clavate to spathulate, yellow brown to dark brown, thick-walled, up to 200 µm long, protruding from the central plexus of hyphae or from the spore base. The apices of "paraphysis-like" structures tightly packed, forming a peridium enclosing the whole sporocarp. Chlamydospores cylindro-clavate to obvoid, (27.5-) 40-65 (-75) x (50-) 72.5-132.5 µm, brown to reddish brown, sometimes with a septum at the spore base.

Chlamydospore walls brown to reddish brown, 7.5-25 µm thick at their apices, 6-10 µm thick at the base, and 2-5 µm thick at the sides. Sometimes, hyaline, thick-walled (up to 6 µm thick) structures with a membraneous outer coat are present within the chalmydospores.

**COLLECTIONS EXAMINED**: **1**. TAIWAN:Taipei, Holotype, from the rhizosphere of *Liquidambar formosana* Hance, Wu-860203; **2**. TAIWAN:Taipei, Isotype, Wu-860627; **3**. TAIWAN:Taipei, Paratype, Wu-860627; **4**. TAIWAN: Kao-shiung, Liou-Kuei, from the rhizosphere of *Cunninghamia lanceolata* (Lamb.) Hook, Wu-870117.

**NOTES**: *Sclerocystis liquidambaris* produces two sizes of chlamydospores similar to those of *S. clavispora* (Fig. 19A). Spore size falls into two major categories, one 6000-7000 µm$^2$ and the other 2000-3000 µm$^2$. *Sclerocystis liquidambaris* differs from *S. clavispora* mainly by its "paraphysis-like" structures which protrude out of sporal layer and form a "pseudoperidium". This species was also found in Korea (Koo *et al.*, 1992; Eom *et al.*, 1992).

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Figure 15. Diagram of *S. liquidambaris*. A. Chlamydospores surrounded by thick-walled, "paraphysis-like" structures, emerging from the level of the sporophores. B. Chlamydospores. Note two different size calsses.

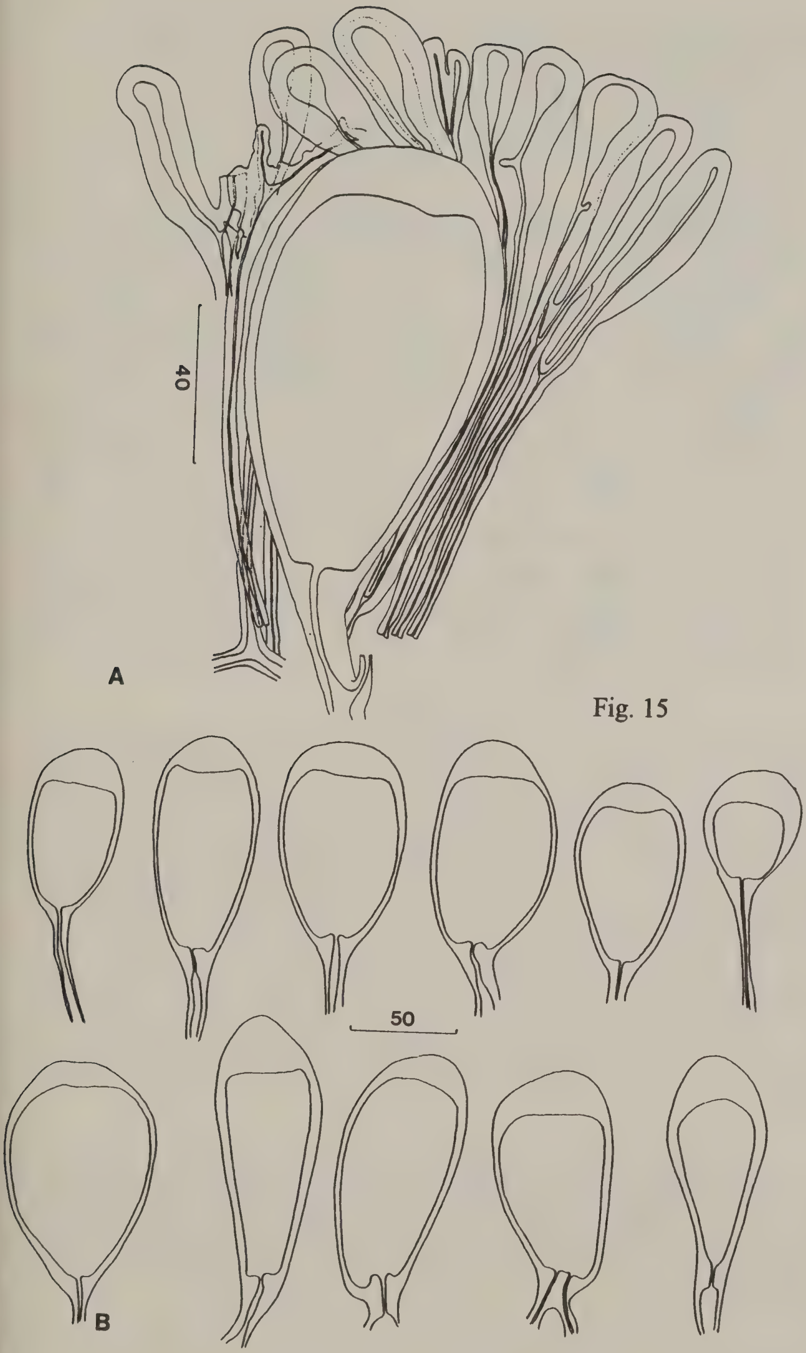

Fig. 15

**4. *Sclerocystis rubiformis*** Gerdemann & Trappe, Mycologia Memoir No. 5:60-63, 1974. (Figures 7, 16)
= *Sclerocystis indicus* Bhattacharjee, Mukerji & Misr. Acta Botanica Indica 8:99-100, 1980.
= *Sclerocystis pachycaulis* Wu & Chen, Taiwania 31: 74-75, 1986.

Sporocarps yellow to yellow brown, globose to subglobose, 150-300 x 190-360 µm. In young sporocarps, chlamydospores are arranged in a hemispherical layer. However, with the subsequent formation of additional chlamydospores, these immature sporocarps are transformed into globular sporocarps with radially arranged chlamydospores. Chlamydospores are arranged on a thick-walled central plexal cell which is connected with a broad hyphal stalk. Perdium unknown. Chlamydospores yellow to yellow brown, obovoid to ellipsoid, sometimes irregular, 27.5-60 x 37.5-87.5 µm. Chlamydospore wall yellow-brown, 1-5(-7.5) µm thick, with a hyaline, separable outer layer, 0.5-1 µm thick. Usually chlamydospore contents separated by 1-2 adventituous septa below the region of attached hypha. Attached hyphae 7.5-15 µm diam, sometimes with a thick wall up to 7.5 µm that tapers for some distance.

COLLECTIONS EXAMINED: **1.** TAIWAN: Chi-tou, from the rhizosphere of *Gonostegia hirta* (Blume) Miq., Wu-043; **2.** TAIWAN: Chi-tou, from the rhizosphere of *Polygonum hydropiper* L., Wu-044; **3.** TAIWAN: Chi-tou, from the rhizosphere of *Phyllostachys pubescens* Mazel, Wu-045; **4.** TAIWAN: Chi-tou, from the rhizosphere of *Microstegium geniculatum* (Hayata) Honda, Wu-046; **5.** TAIWAN: Chi-tou, from the rhizosphere of *Asplenium normales* Don., Wu-047; **6.** TAIWAN: Chi-tou, from the rhizosphere of *Erechthites valerianifolia*, Wu-8508203; **7.** TAIWAN: Chi-tou, from the rhizosphere of *Gingo biloba*, Wu-8508204; **8.** TAIWAN: Chi-tou, from the rhizosphere of *Colocasia formosanum*, Wu-8607153; **9.** TAIWAN: Kenting, from the rhizosphere of *Colocasia formosanum*, Wu-8605172.

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Figure 16. Diagram of chlamydospores and sporocarps of *S. rubiformis*. Note the two young, broomlike sporocarps each with a thick-walled hyphal stalk and the chlamydospores enclosed by a hyaline, separable outer wall.

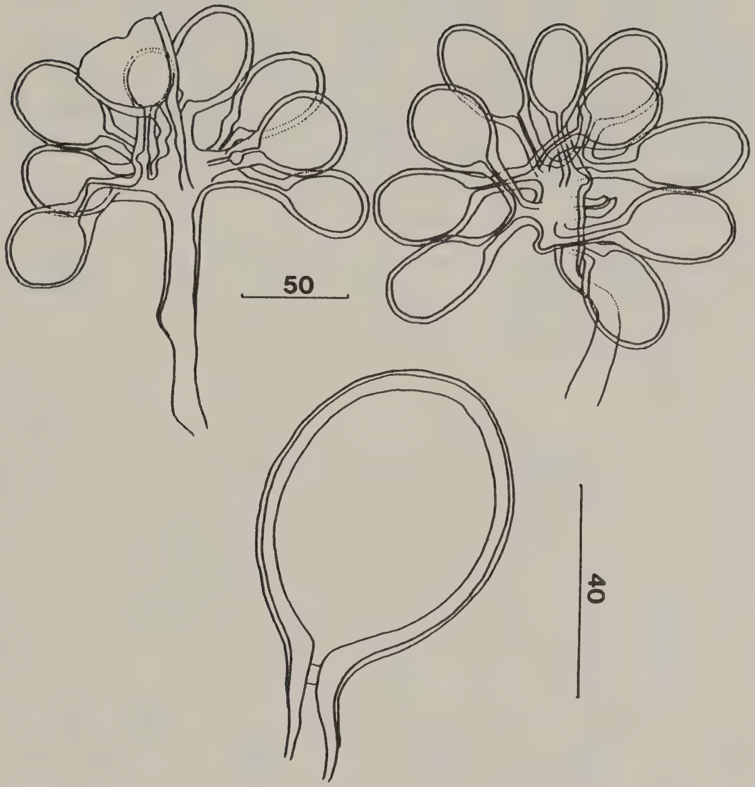

Fig. 16

NOTES: Spores of this species are in the same size range as those produced by *S. taiwanensis* (Fig. 19B). The plexal hypha of *S. rubiformis* is a broad, thick-walled cell around which spores are produced and is different from that of *S. taiwanensis* because the latter plexal hypha is formed by the fusion of more than one monohyphal stalk. Another similarity between *S. rubiformis* and *S. taiwanensis* is that their spores are enclosed by a separable hyaline outer layer.

5. ***Sclerocystis sinuosa*** Gerdemann & Bakshi, Trans. Br. Mycol. Soc. 66:340-343, 1976. (Figures 9, 11, 12, 17)
= *S. pakistanica* Iqbal & Bushra, Trans. Mycol. Soc. Japan 21:59-60, 1980.

Sporocarps reddish-brown to dull brown, globose to subglobose, 248-580 x 380-650 µm. Peridium tightly enclosing a sporocarp, composed of thick-walled interwoven hyphae. In the younger collections ( *i.e.*, spores containing numerous oil droplets and spore wall usually evenly thickened), peridial hyphae sinuous. In the older collections ( *i.e.*, spores with much less cellular contents, often infected by other fungi, perforated, and spore wall often thickened at apex or lateral side ), sinuous feature may appear indistinct. Chlamydospores (22.5-) 35-74 (-87.5) x (47.5-) 55-125 (-145) µm, globose, subglobose, obovoid, ellipsoidal, clavate, or irregular, wall single, with walls either evenly thickened or unevenly thickened, usually thickened at the apex or lateral side, (1.5-) 5-22.5 (-30) µm, with 1-2 attached hyphae. Chlamydospores often infected by other soil microorganisms and "*Glomus*-like" endospores also frequently formed inside.

COLLECTIONS EXAMINED: **1.** TAIWAN: Tainan, Anpin; from the rhizosphere of *Miscanthus* sp. in *Casuarina equisetifolia L* . woods, Wu-850725; **2.** TAIWAN: Tainan, Anpin; from the rhizosphere of ground covers in *C. equisetifolia L.* woods, Wu-850918; **3.** TAIWAN: Pintong, by Kau-ping River; from the rhizosphere of legume (*Glycine* sp.), Wu-860814 a; **4.** TAIWAN: Pintong, by Kau-ping River; from the rhizosphere of asparagus (*A. officinalis*), Wu-860813; **5.** TAIWAN: Pintong, Tongang;

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Figure 17. Diagram of heterogenous chlamydospores of *S. sinuosa*. Note *Glomus*-like endospores frequently found within chlamydospores.

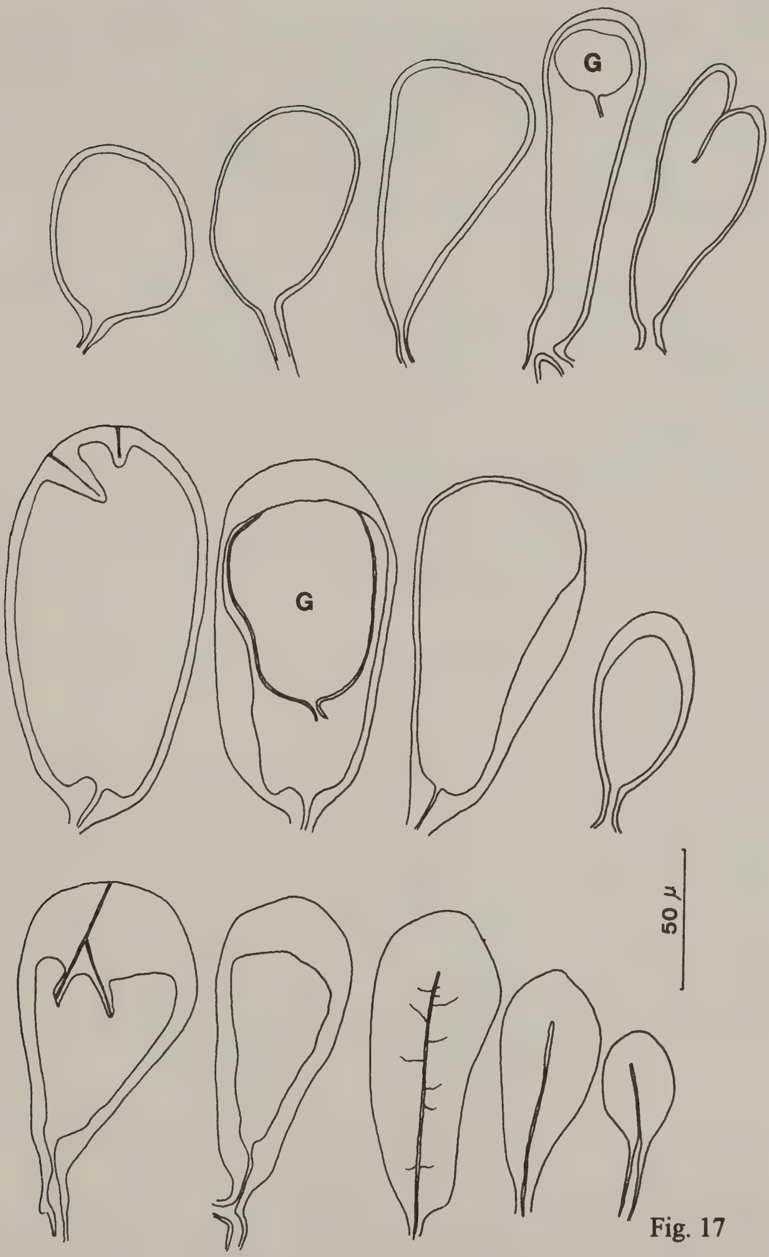

Fig. 17

from the rhizosphere of unidentified herb grass, Wu-ME2; **6**. TAIWAN: Tainan, Charlu; from the rhizosphere of orange (*Citrus* sp.), Wu-860814 b; **7**. TAIWAN: Nantou, Chi-tou, from the rhizosphere of *Sinocalamus* sp., Wu-850814; **8**. TAIWAN: Taichung, Wu-feng, from the rhizosphre of maize (*Zea mays* L.), Wu-111401; **9**. TAIWAN: Orchid Island, Taitung, from the rhizosphere of *C. equisetifolia*, Wu-860707; **10**. U.S.A., INVAM collection, Gainesville, Florida (SSNS 122).

**NOTES**: The indistinct sinuous feature of the peridium of mature sporocarps and the thickened peridium may lead to confusion in identifying this species. *Sclerocystis pakistanica* was described from such materials. Spores with unevenly thickened walls are frequently found in the sporocarps isolated from crop fields or beach sand dunes. The bore holes and internal projections of spore wall (Fig. 17) are probably caused by fungi and actinomycetes (Lee, 1991). Sporocarps usually arise from two to four monohyphal stalks (Wu, 1993). The heterogenous spores with uneven wall thickness and indistinct sinuous feature have been illustrated by Wu and Chen (1993).

**6. *Sclerocystis taiwanensis*** Wu & Chen, Trans. Mycol. Soc. Rep. China 2: 73-83, 1987. (Figures 8, 10, 18)

Sporocarps reddish brown, brown or dark brown, globose, subglobose or ellipsoidal, 200-300 x 180-280 µm, with chlamydospores formed radially in a single, tightly packed layer around a central plexus of hyphae. Peridium lacking. Chlamydospores 40-85(-105) x (17.5-)22-42.5(-55) µm, clavate, cylindro-clavate, triangular or irregular, with or without a septum at the spore base. Chlamydospore wall laminate or single, with a hyaline, separable outer layer (ca. 1 µm), yellow, yellow-brown, sometimes olive-brown, (4-)7.5-22.5(-25) µm thick at the apex, 1.5-5 µm thick at the sides, generally thickest at the apex.

**COLLECTIONS EXAMINED**: **1**. TAIWAN: Chi-tou, Holotype, from the rhizosphere of *Crassocephalum rabens* (Juss. ex Jacq.) S. Moore, Wu-

Figure 18. Diagram of sporocarps and chlamydospores of *S. taiwanensis*. A. Young sporocarp connected with five monohyphal stalks. Note spores still in vesicular appearance. B. Mature chlamydospores and pedate plexal cell. Note some vesicle-like young spores formed from plexal cell.

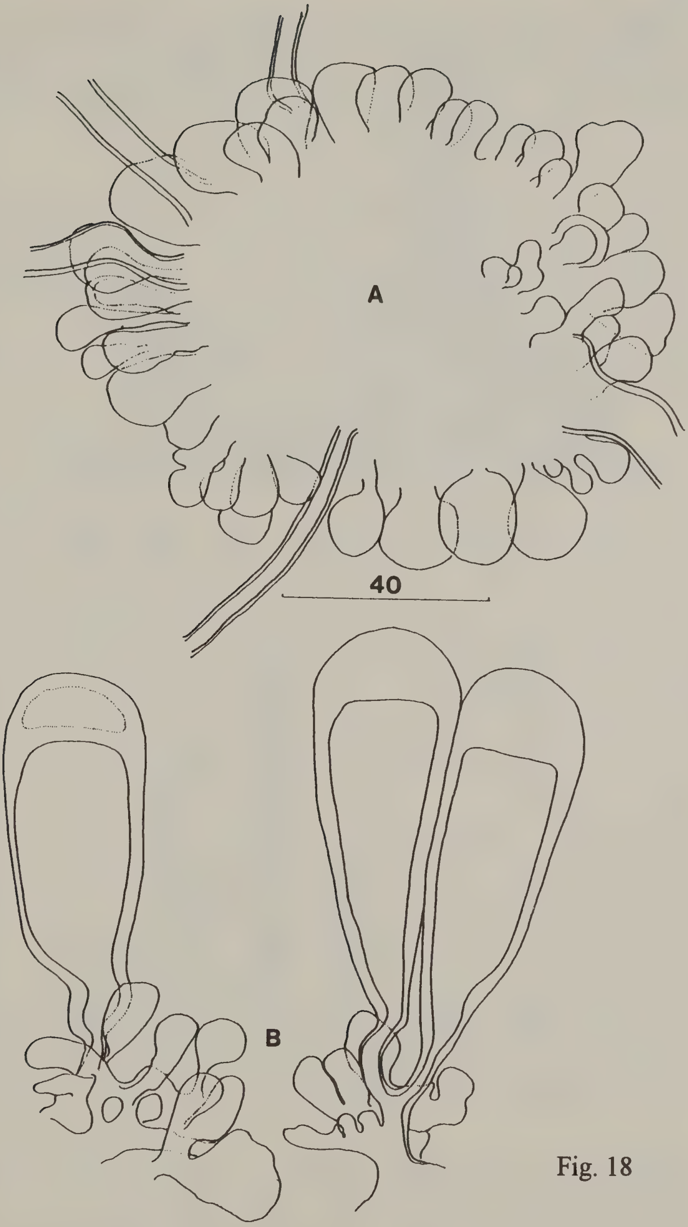

Fig. 18

8508205; **2**. TAIWAN: Chi-tou, from the rhizosphere of *Colocasia formosanum*, Wu-8607154; **3**. TAIWAN: Taipei, from the rhizosphere of unknown host, Wu-850810; **4**. TAIWAN: Tainan, from the rhizosphere of orange (*Citrus sinensis* Osb.), Wu-850724.

NOTES: *Sclerocystis taiwanensis* is very similar to *S. rubiformis*. However, the spores of former species are tightly packed around a central plexus which is formed by the fusion of more than one monohyphal stalk. Spores of the latter are only loosely arranged around a broad, thick-walled stellate cell. *Sclerocystis taiwanensis* was recently isolated from Korea (Koo *et al.*, 1992; Eom *et al.*, 1992) and Philippines (personal communication).

## DISSCUSSION

The evolutionary affinities among these six species has been previously described (Wu, 1993). Sporocarps of *S. rubiformis* are considered primitive, due to their lack of a peridium and producing sporocarps from a simple, broad, thick-walled plexal cell. In the naked sporocarps of *S. taiwanensis*, the central plexus is more complicated than that of *S. rubiformis* and is formed by the fusion of more than one monohyphal stalk. *Sclerocystis clavispora* produces sporocarps similar to *S. taiwanensis*, but the central plexus is replaced by interwoven hyphae and is thought to be advanced to *S. taiwanensis*. *Sclerocystis liquidambaris* appears to be derived from the *S. clavispora/S. taiwanensis* type, with the hyphal branches arising from the base of the spores becoming thick-walled. The peridium of *S. liquidambaris* is thought primitive if compared with that of *S. sinuosa* and *S. coremioides*, since it is only tightly packed by thick-walled, clubshaped cells. In the sporocarps of *S. sinuosa* and *S. coremioides*, however, a peridium of interwoven hyphae is well developed. *Sclerocystis sinuosa* has a number of monohyphal stalks radiating out of sporocarps. The monohyphal stalks of *S. coremioides* are combined into a coarse stipe. A single monohyphal

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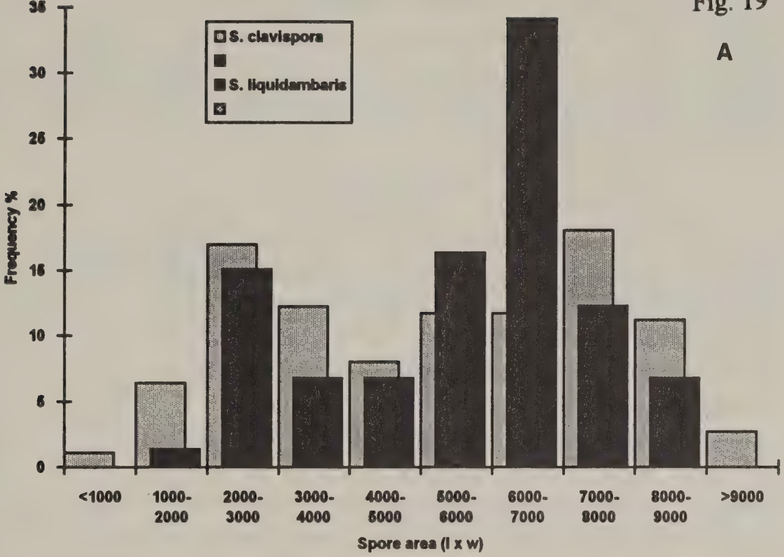
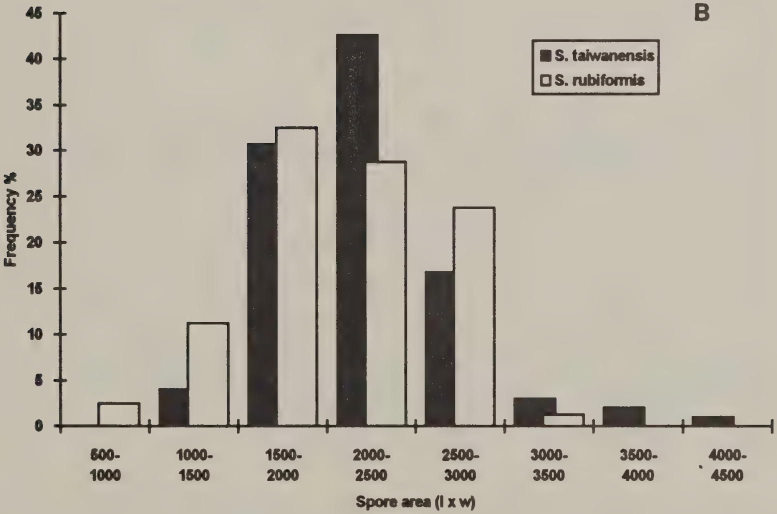
Figure 19A. Comparative diagram of spore area frequency in *S. clavispora* and *S. liquidambaris*. Both species show two peaks in the distribution curves. Figure 19B. Comparative diagram of spore area frequency in *S. rubiformis* and *S. taiwanensis*. Both species show very similar distribution curves.

Fig. 19



A
S. clavispora
S. liquidambaris
Frequency %
0
5
10
15
20
25
30
35
<1000
1000-2000
2000-3000
3000-4000
4000-5000
5000-6000
6000-7000
7000-8000
8000-9000
>9000
Spore area (l x w)



B
S. taiwanensis
S. rubiformis
Frequency %
0
5
10
15
20
25
30
35
40
45
500-1000
1000-1500
1500-2000
2000-2500
2500-3000
3000-3500
3500-4000
4000-4500
Spore area (l x w)

stalk has the ability to produce a broomlike fruiting body, and further develops into a globose sporocarp. However, the fusing of many monohyphal stalks into a stipe would result in a loss of the ability to produce spores in a globular arrangement, but finally producing a hemispherical sporocarp.

In this monograph, the spore area (length x width)/frequency diagrams for these six species (Fig. 20) show that (i) *S. rubiformis* and *S. taiwanensis* consistently produce small spores (Fig. 19B), (ii) *S. clavispora* and *S. liquidambaris* produce spores mainly in two different sizes (smaller and larger) (Fig. 19A), and (iii) *S. sinuosa* and *S. coremioides* produce mostly medium sized spores (Fig. 20). These results are thought to support previous suggestions that *S. rubiformis* and *S. taiwanensis* are the most primitive species, because (a) their sporocarps are very simple, small, and not enclosed by peridium, and (b) they produce smaller spores. The sporocarp structures of *Sclerocystis clavispora* and *S. liqudiambaris* are more advanced than *S. rubiformis* and *S. taiwanensis,* and tend to produce larger spores. Since both are in a transitional stage connecting the primitive *S. rubiformis/S. taiwanensis* group and advanced *S. sinuosa/S. coremioides* group, they produce both smaller and larger spores. The sporocarps of *S. liquidambaris* are enclosed by "paraphysis-like" structures which result in limited space for sporulation; therefore, the number of smaller spores is comparatively fewer than *S. clavispora*. *Sclerocystis sinuosa* and *S. coremioides* are highly advanced species and have vigorous ability to produce spores. Due to the presence of a peridium and the influence of limited space in the sporocarp, sporulation is constrained and most of the spores produced are of a medium size. However, the spore size of *S. coremioides* was closer to that of *S. rubiformis* and *S. taiwanensis*, because all of the monohyphal stalks were already fused into a hyphal stipe and thus, it has lost the ability to produce more and larger spores.

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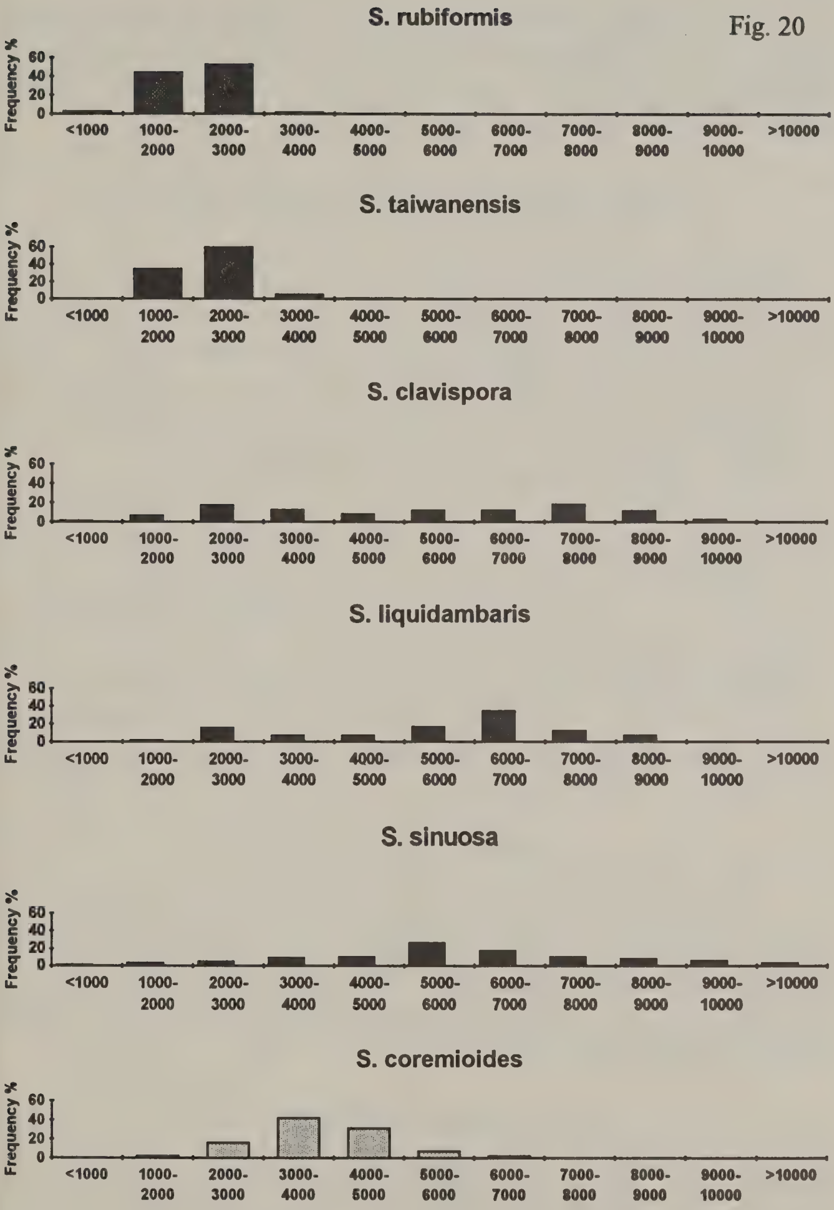
Figure 20. Comparative diagram of spore area frequency in *S. calvispora*, *S. coremioides*, *S. liquidambaris*, *S. rubiformis*, *S. sinuosa*, and *S. taiwanensis*. Both *S. rubiformis* and *S. taiwanensis* produce smaller spores. *Sclerocystis liquidambaris* and *S. clavispora* mainly produce two types of spores, one smaller and another larger in size. The spore area frequency diagram of *S. sinuosa* and *S. coremioides* shows that only medium-sized spores are produced.

Fig. 20


S. rubiformis
S. taiwanensis
S. clavispora
S. liquidambaris
S. sinuosa
S. coremioides
Frequency %
0
20
40
60
<1000
1000-2000
2000-3000
3000-4000
4000-5000
5000-6000
6000-7000
7000-8000
8000-9000
9000-10000
>10000

Some species of *Sclerocystis* are only isolated from non-disturbed areas, such as *S. rubiformis* and *S. taiwanensis* which are found in natural reservations. *Sclerocystis coremioides* and *S. sinuosa* are widely distributed in Taiwan.

## KEYS TO THE SPECIES OF *SCLEROCYSTIS*

1. Sporocarps not enclosed in a peridium..........................................2
1. Sporocarps enclosed in a peridium... ..............................................4
2. Sporocarps with a monohyphal stalk; chlamydospores raidally arranged on a broad, thick-walled plexal cell....................*S. rubiformis*
2. Sporocarps with more monohyphal stalks; plexus not a broad, thick-walled cell; chlamyspores thightly arranged side by side....................3
3. Sporocarps relatively small, <300 mm; chlamydospore with a separable hyaline outer wall........... .............................*S. taiwanensis*
3. Sporocarps large up to 800 mm; chlamydospore without a separable hyaline outer wall......... ................................*S. clavispora*
4. Peridium composed of a layer of club-shaped cells.....*S. liquidambaris*
4. Peridium composed of interwoven hyphae.......................................5
5. Sporocarps not hemispherical; peridium showing sinuous feature; if indistinct, spores with varialbe thickness.............................*S. sinuosa*
5. Sporocarps hemispherical, with a hyphal stalk which may connect into a column or branched appearance ...............................*S. coremioides*

## ACKNOWLEDGEMENT

This research was financially supported by The National Science Council of Taiwan, Republic of China (NSC 82-0409-B-055-013). Appreciation is extended to Drs. R. E. Koske, James W. Kimbrough, and G. L. Benny for their critical reviews of this manuscript and for providing specimens used in this research.

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# Notes on Korean Cercosporae and Allied Genera (1)

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The species of *Cercospora* and allied genera in Korea are poorly known and not yet intensively studied. Some phytopathological papers (Nakata & Takimoto 1928, Park 1967, Anonymous 1986) listed about 70 species of this group of fungi. The species reported in the present paper were collected by H.D. Shin in the central part of Korea between 1990 and 1992. Forty species are listed, including 4 new species, 2 new combinations and 23 new records for Korea. The new species *Neoramularia bidentis*, *Phaeoramularia valerianicola*, *Pseudocercosporella paridicola* and *Stenella dianthi* are described. All specimens, including type collections, are deposited in the Herbarium of the Department of Horticulture, Kangnung National University, Kangnung, Korea. Deplicates are housed in HAL.

(1) *Cercospora althaeina* Sacc., Michelia 1:269 (1878).
On *Althaea rosea* Cav., Kangnung, Korea, 31 X 1990, Shin.

(2) *Cercospora armoraciae* Sacc., Nuovo Giorn. bot. Ital. 8:180 (1876).
On *Armoracia lapathifolia* Gilib., Suwon, Korea, 29 VII 1991, Shin.

(3) *Cercospora beticola* Sacc., Nuovo Giorn. bot. Ital. 8:189 (1876).
On *Beta vulgaris* var. *cicla* L., Kangnung, Korea, 13 IX 1990, Shin.

(4) *Cercospora canescens* Ellis & Martin, Amer. Nat. 16:1003 (1882).
On *Phaseolus angularis* W.F. Wight, Yangku, Korea, 12 IX 1992, Shin.

(5) *Cercospora capsici* Heald & Wolf, Mycologia 3:15 (1911).
On *Capsicum annuum* L., Kangnung, Korea, 10 X 1992, Shin.

(6) *Cercospora dubia* (Riess) Winter, in Rabenh., Fungi eur. extra-eur. exs., cent. 8 (resp. cent. 28). No. 2780, Dresden (1882).
On *Chenopodium ficifolium* Smith, Kangnung, Korea, 5 IX 1991. Shin.

(7) *Cercospora ipomoeae* Winter, Hedwigia 26:34 (1887).
On *Pharbitis nil* Chois., Chunchon, Korea, 10 IX 1992, Shin.

(8) *Cercospora lactucae-sativae* Sawada, Formos. agr. Res. Inst. Rep. 35:111 (1928).
Syn.: *C. longissima* Cugini ex Trav. (= homonym!)
*C. lactucae* Stev. (= homonym!)
On *Lactuca indica* var. *laciniata* (O. Kuntze) Hara, Hongchon, Korea, 20 IX 1992, Shin.
On *Lactuca sativa* L., Kangnung, Korea, 19 VI 1992, Shin.

(9) *Cercospora lycii* Ellis & Halsted, Journ. Mycol. 4:7 (1888).
On *Lycium chinense* Mill., Chunchon, Korea, 10 IX 1992, Shin.

(10) *Cercospora polygonacea* Ellis & Everh., Journ. Mycol. 1:24 (1885).
On *Persicaria blumei* Gross, Hongchon, Korea, 20 IX 1992, Shin.
On *Persicaria thunbergii* H. Gross, Kangnung, Korea, 2 VIII 1992, Shin.

(11) *Cercospora violae* Sacc., Nuovo Giorn. bot. Ital. 8:187 (1876).
On *Viola hodoensis* W. Becker & H. Boiss, Kangnung, Korea, 6 XI 1991, Shin.
On *Viola rosii* Hemsl., Kangnung, Korea, 31 X 1990, Shin.
On *Viola verecunda* A. Gray, Kangnung, Korea, 4 VII 1991, Shin.

(12) *Cercospora zebrina* Passerini, Hedwigia 16:124 (1877).
On *Trifolium repens* L., Kangnung, Korea, 22 X 1991, Shin.

(13) *Cercospora zinniae* Ellis & Martin, Journ. Mycol. 1:20 (1885).
On *Zinnia elegans* Jacq., Kangnung, Korea, 21 X 1990, Shin.

(14) *Distocercospora pachyderma* (H. & P. Sydow) Pons & B. Sutton, Mycol. Papers 160:60 (1988).
On *Dioscorea tokoro* Makino, Myongju, Korea, 26 IX 1991, Shin.

(15) *Mycovellosiella passaloroides* (Winter) Bai & Cheng, Acta Mycol. Sin. 11(2):120 (1992).
On *Amorpha fruticosa* L., Myongju, Korea, 6 X 1991, Shin.

(16) *Neorumularia bidentis* spec. nov. Fig. 1.

Maculae amphigenae, suborbiculares vel leniter irregulares, purpureo-atrobrunneae, 2-5 mm diam., margine indistincto, vel confluentes (-10 mm diam.), magnae flavido-brunneae, margine atropurpureo cinctae. Caespituli saepe hypophylli, per venas emergenti. Mycelium immersum. Stroma nullum. Conidiophora solitaria vel laxe aggregata, per cuticulam erummpentia, ca. 20-32(-55) x 4(-7) µm, hyalina, cylindrica, erecta, basi incrassata, apice leniter attenuata, (0-)1-2 septata, late rotundata vel subtruncata. Cicatrices

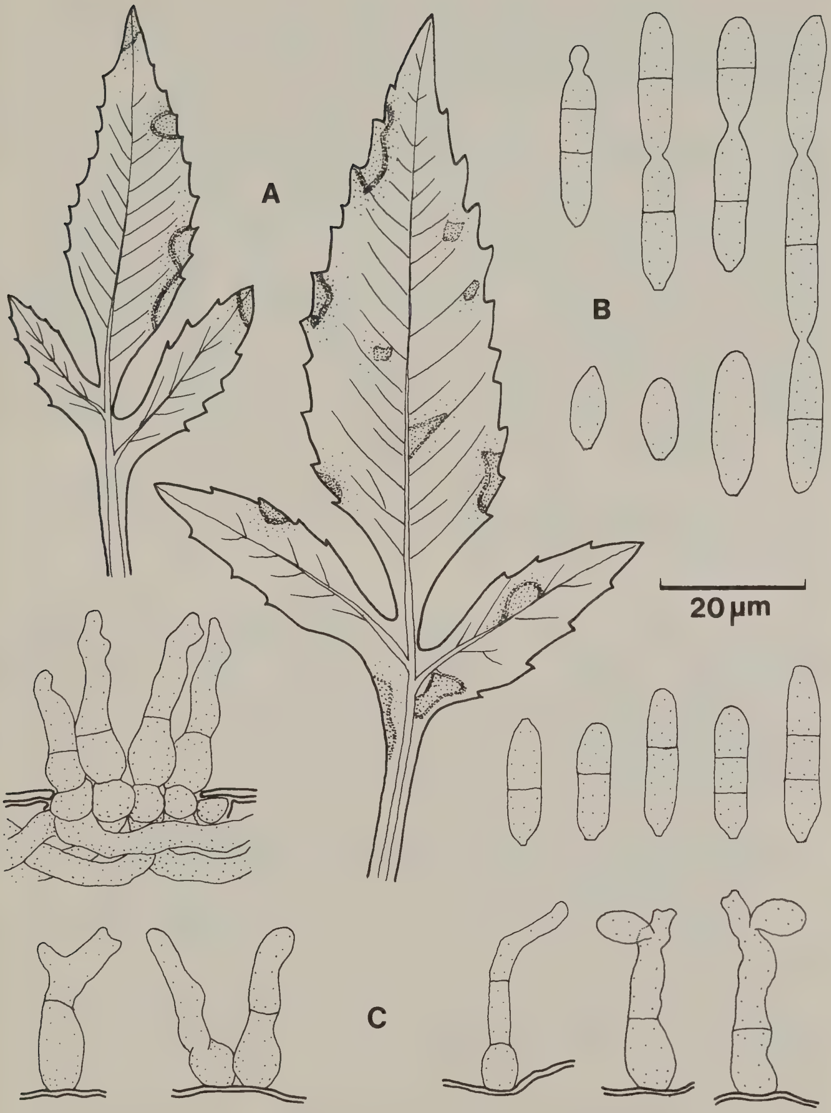

Fig. 1. *Neoramularia bidentis* : A, Hypophyllous leaf spots; B, Conidia; C, Conidiophores. H.D. Shin del.

conidiales inconspicuae, non incrassatae. Conidia solitaria vel catenata, 10–34 x (2.5–)3.5–5 µm, hyalina, 0–2 septata, laevia, cylindrica vel cylindro-fusiformia, apice subobtusa vel subobconica, basi subobconica vel subtruncata, hila non incrassata.

Leaf spots amphigenous, scattered and marginal, suborbicular to somewhat irregular, ca. 2–5 mm diam., or confluent, up to 10 mm diam., at first dark purplish brown, without definite border, later yellowish brown, with dark purplish margin. Caespituli chiefly hypophyllous, usually on veins. Mycelium internal. Stromata absent. Conidiophores solitary or in small, loose groups, erumpent through the cuticle, ca. 20–32(–55) x 4 µm, but up to 7 µm wide at the bulbose base, hyaline, cylindric, erect, with slightly bulbose base, usually somewhat narrowed towards the tips, (0–)1–2-septate, very rarely branched, broadly rounded or subtruncate at the apex, conidial scars inconspicuous, unthickened, not darkened. Conidia solitary or catenate, 10–34 x (2.5–)3.5–5 µm, hyaline, 0–2-septate, smooth, cylindric to cylindric-fusiform, apex subobtuse or subobconic, base subobconic or subtruncate, hila unthickened.

Holotypus: On *Bidens tripartita* L. (Compositae), Kangnung, Korea, 29 VIII 1992, Shin (Herbarium, Department of Horticulture, Kangnung National University).
Isotypus: HAL.

This fungus is *Ramularia*-like, but differs by unthickened, inconspicuous conidial scars and hila. Braun (1991, 1992) introduced the genus *Neoramularia* for *Ramularia*-like species with unthickened, inconspicuous conidial scars. *N. bidentis* is a very unusual fungus. It is distinguished from all known *Neoramularia* species by mostly solitary conidiophores, erumpent through the cuticle. Nevertheless, we tentatively place this species in *Neoramularia* until the full morphological variability of the genus is known.

(17) *Passalora miurae* (H. & P. Sydow) U. Braun & Shin comb. nov.
Bas.: *Cercospora miurae* H. & P. Sydow, Ann. Myc. 11:117 (1913).
Syn.: *Cercosporidium miurae* (H. & P. Sydow) Liu & Guo, Acta Mycol. Sinica 1(2):98 (1982).
On *Metaplexis japonica* (Thunb.) Makino, Chunchon, Korea, 2 X 1991, Shin.

Note: This species is characterized by fairly short, broad conidia with few speta and *Passalora*-like conidial scars (only slightly thickened and darkened).

(18) *Phacellium episphaerium* (Desm.) U. Braun, Nova Hedwigia 50 (3-4):509 (1990).
On *Stellaria aquatica* Scop., Kangnung, Korea, 23 XI 1991, Shin.
On *Stellaria media* Villars, Kangnung, Korea, 13 XI 1990, Shin.

(19) *Phaeoisariopsis griseola* (Sacc.) Ferraris, Ann. Myc. 7:280 (1909).
On *Phaseolus vulgaris* L., Yangku, Korea, 17 VII 1992, Shin.

(20) *Phaeoramularia valerianicola* spec. nov. Fig. 2.

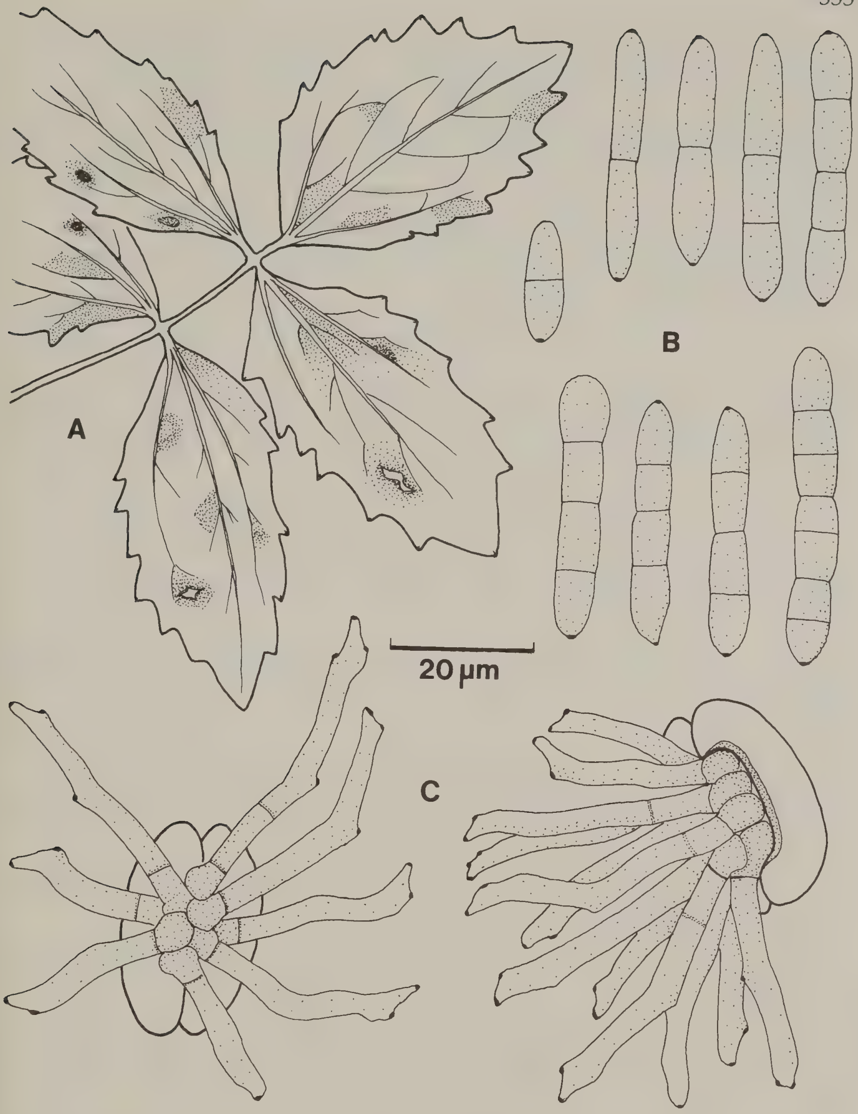

Fig. 2. *Phaeoramularia valerianicola* : **A**, Hypophyllous leaf spots; **B**, Conidia; **C**, Conidiophores. H.D. Shin del.

Maculae amphigenae, angulares vel irregulares, saepe per venas limitatae, 2-20 mm diam., atrobrunneae. Caespituli hypophylli. Mycelium immersum. Stromata parva, bene evoluta, substomatalia, ex hyphis inflatis, pallide olivaceis compositum. Conidiophora dense vel laxe fasciculata (ca. 6-20), 20-54 x 3-5 µm, pallide viridula, olivacea, 0-2 septata, non ramosa, laevia, geniculata. Cicatrices conidiales conspicuae, minutae, incrassatae, obscurae. Conidia solitaria vel saepe catenata, 16-52 x 4-7.5 µm, cylindrica, recta, pallide viridula, (0-)1-3(-6) septata, saepe constricta, laevia, apice late rotundata vel breviter obconica, basi rotundata, hila leniter incrassata et obscura.

Leaf spots amphigenous, polygonal to irregular, usually vein-limited, 2-20 mm diam., dark brown, with greenish yellow halo. Caepituli hypophyllous. Mycelium internal. Stromata small, well developed, substomatal, composed of swollen hyphae, very pale olivaceous. Conidiophores fasciculate (ca. 6-20), fascicles dense, erect to loose, divergent, 20-54 x 3-5 µm, pale greenish, olivaceous, 0-2-spetate, not branched, smooth, geniculate, conidial scars small, conspicuously thickened, somewhat darkened. Conidia solitary or catenate, 16-52 x 4-7.5 µm, cylindric, straight, pale greenish,(0-) 1-3(-6)-septate, usually constricted at the septa, smooth, apex broadly rounded or shortly obconic, base rounded, hila somewhat thickened and darkened.

Holotypus: On *Valeriana fauriei* Briq. (Valerianaceae), Kangnung, Korea, 10 VIII 1992, Shin (Herbarium, Department of Horticulture, Kangnung National University).
Isotypus: HAL.

*Ramularia valerianae* (Speg.) Sacc. (Syll. Fung. 4:207, 1886) differs from this fungus by colourless conidiophores and 0-1-septate, non constricted, colourless and shorter conidia.

(21) *Pseudocercospora atromarginalis* (Atk.) Deighton, Mycol. Papers 140:139 (1976).
On *Solanum nigrum* L., Kangnung, Korea, 28 IX 1991, Shin.

(22) *Pseudocercospora cydoniae* (Ellis & Everh.) U. Braun & Shin comb. nov.
Bas.: *Cercospora cydoniae* Ellis & Everh., Journ. Mycol. 8:72 (1902).
On *Chaenomeles lagenaria* (Loisel) Koidz., Suwon, Korea, 5 X 1991, Shin.

Note: The conidial scars in this species are inconspicuous and unthickened, hence it must be transferred to *Pseudocercospora*.

(23) *Pseudocercospora destructiva* (Ravenel) Guo & Liu, Acta Mycol. Sin. 11(2):131 (1992).
On *Euonymus japonicus* Thunb., Kangnung, Korea, 13 IX 1991, Shin.

(24) *Pseudocercospora diospyri-morrisianae* Goh & Hsieh, Trans. mycol. Soc. R.O.C. 2(2):90 (1987).
On *Diospyros latus* L., Kangnung, Korea, 3 X 1991, Shin.

(25) *Pseudocercospora humuli-japonici* Goh & Hsieh, Cercospora and Similar Fungi from Taiwan, p. 239 (1990).
On *Humulus japonicus* S. & Z., Kangnung, Korea, 31 X 1990, Shin.

(26) *Pseudocercospora ligustri* Deighton, Mycol. Papers 140:78 (1976).
On *Ligustrum obtuisifolium* S. & Z., Kangnung, Korea, 29 X 1992, Shin.

Notes: This collection is somewhat different from North American materials (cf. Deighton 1976); conidiophore fascicles are smaller, superficial secondary mycelium is only poorly developed, and conidia are only 0–3-septate, somewhat wider, and usually not obconically truncate but sometimes with truncate unthickened scars at both ends (conidia in chains?).

(27) *Pseudocercospora lonicericola* (Yamam.) Deighton, Mycol. Papers 140:146 (1976).
On *Lonicera japonica* Thunb., Kangnung, Korea, 15 X 1991, Shin.

(28) *Pseudocercospora profusa* (H. & P. Sydow) Deighton, Trans. Brit. mycol. Soc. 88(3):388 (1987).
On *Acalypha australis* L., Kangnung, Korea, 8 IX 1989, Shin.

(29) *Pseudocercospora puerariicola* (Yamam.) Deighton, Mycol. Papers 140:151 (1976).
On *Pueraria thunbergiana* Benth., Kangnung, Korea, 25 IX 1991, Shin.

(30) *Pseudocercospora rhoina* (Cooke & Ellis) Deighton, Mycol. Papers 140:152 (1976).
On *Rhus chinensis* Mill., Myongju, Korea, 6 X 1991, Shin.

(31) *Pseudocercospora vitis* (Lév.) Spegazzini, Ann. Mus. nac. His. nat. B. Aires 20:438 (1910).
On *Ampelopsis brevipeduculata* var. *heterophylla* (Thunb.) Hara, Suwon, Korea, 19 VIII 1991, Shin.
On *Vitis amurensis* Rupr., Myongju, Korea, 31 VIII 1991, Shin.

(32) *Pseudocercosporella capsellae* (Ellis & Everh.) Deighton, Mycol. Papers 133:42 (1973).
On *Brassica campestris* subsp. *napus* var. *nippo-oleifera* Makino, Kangnung, Korea, 23 XI 1991, Shin.
On *Brassica campestris* subsp. *napus* var. *pekinensis* Makino, Kangnung, Korea, 1 XI 1991, Shin.

(33) *Pseudocercosporella paridicola* spec. nov. Fig. 3

Maculae amphigenae, suborbiculares, pallide viridae, flvido-brunneae, saepe 10–15 mm diam., margine atrobrunneo cinctae. Caespituli amphigeni, albidi. Mycelium immersum. Stromata parva, intraepidermalia, hyalina, ex cellulis inflatis compositum. Conidiophora solitaria vel laxe fasciculata (-20), ex cellulis stromatibus intraepidermalibus oriunda, per cuticulam erumpentia, hyalina, cylindrica, 10–25(-32) x 4.5-8 µm. Cicatrices conidiales inconspicuae, non incrassatae. Conidia solitaria, (38-)62-148 x 3.5-5 µm, hyalina,

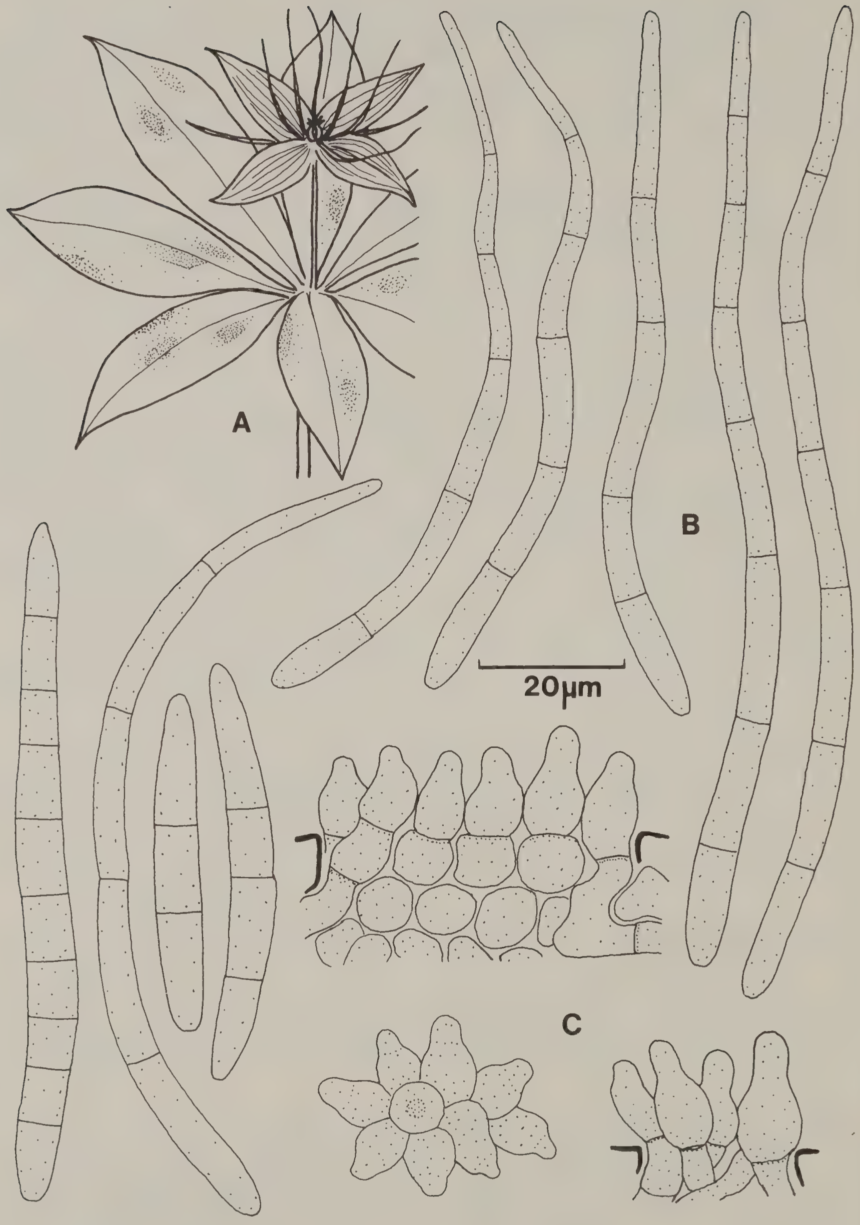

Fig. 3. *Pseudocercosporella paridicola* : **A**, Hypophyllous leaf spots; **B**, Conidia; **C**, Conidiophores. H.D. Shin del.

subcylindrica vel cylindro-fusiformia, laevia, recta vel leniter curvata, 2-7 septata, non constricta, apice subacuta vel subobtusa, basi subtruncata, hila non incrassata.

Leaf spots amphigenous, suborbicular, at first pale greenish, later yellowish brown, mostly 10-15 mm diam., with dark brown margin. Caespituli amphigenous, whitish. Mycelium internal. Stromata small, intra-epidermal, colourless, composed of few swollen cells. Conidiophores produced singly or in loose fascicles of up to 20, arising from stromata, erumpent through the cuticle, colourless, cylindric, short, 10-25(-32) x 4.5-8 µm, conidial scars inconspicuous, unthickened. Conidia solitary, (38-)62-148 x 3.5-5 µm, colourless, subcylindric to cylindric-fusiform, smooth, straight to mildly curved, 2-7-septate, not constricted, apex subacute to subobtuse, base slightly obconically truncate, hila unthickened.

Holotypus: On *Paris verticillata* Bieb. (Liliaceae), Hoenge, Korea, 6 VI 1992, Shin (Herbarium, Department of Horticulture, Kangnung National University).
Isotypus: HAL.

This fungus is related to *Pseudocercosporella inconspicua* (Winter) U. Braun (on *Lilium*) and *P. sublinnealata* (Thüm.) U. Braun (on *Veratrum*), but differs by much smaller stromata and conidiophores produced singly or in small groups.

(34) *Ramularia cirsii* Allescher, Ber. Bayr. Bot. Ges. 2:18 (1892).
On *Cephalonoplos segetum* (Bunge) Kitamura, Chunchon, Korea, 2 XI 1991, Shin.

(35) *Ramularia leonuri* Sorokin, Trudy obsc. estestv. pri. Kazanskom Univ.2:30 (1872).
On *Leonurus sibiricus* L., Chunchon, Korea, 2 XI 1991, Shin.

(36) *Ramularia major* (Unger) U. Braun, Nova Hedwigia 47(3-4):340 (1988).
Syn.: *R. variegata* Ell. & Holm.
On *Petasites japonicus* (S. & Z.) Max., Kangnung, Korea, 3 VII 1991, Shin.

(37) *Ramularia picridis* Fautr. & Roum., Rev. Myc. 14:10 (1892).
On *Picris hieracioides* var. *glabrescens* Ohwi, Hoenge, Korea, 10 VIII 1992, Shin.

(38) *Ramularia rhei* Allescher, Hedwigia 35:34 (1896).
On *Rheum undulatum* L., Chinbu, Korea, 20 VII 1991, Shin.

(39) *Ramularia rubella* (Bon.) Nannf., in Lundell & Nannf., Fungi Exs. Suec. fasc. XXXIX - XL, Sched., p. 33 (1950).
On *Rumex longifolius* DC., Kangnung, Korea, 23 XI 1991, Shin.

(40) *Stenella dianthi* spec. nov. Fig. 4

Maculae amphigeae, orbiculares, 1-3 mm diam., brunneae, margine angusti rubro-brunneo cinctae. Cespituli amphigeni. Mycelium prima-

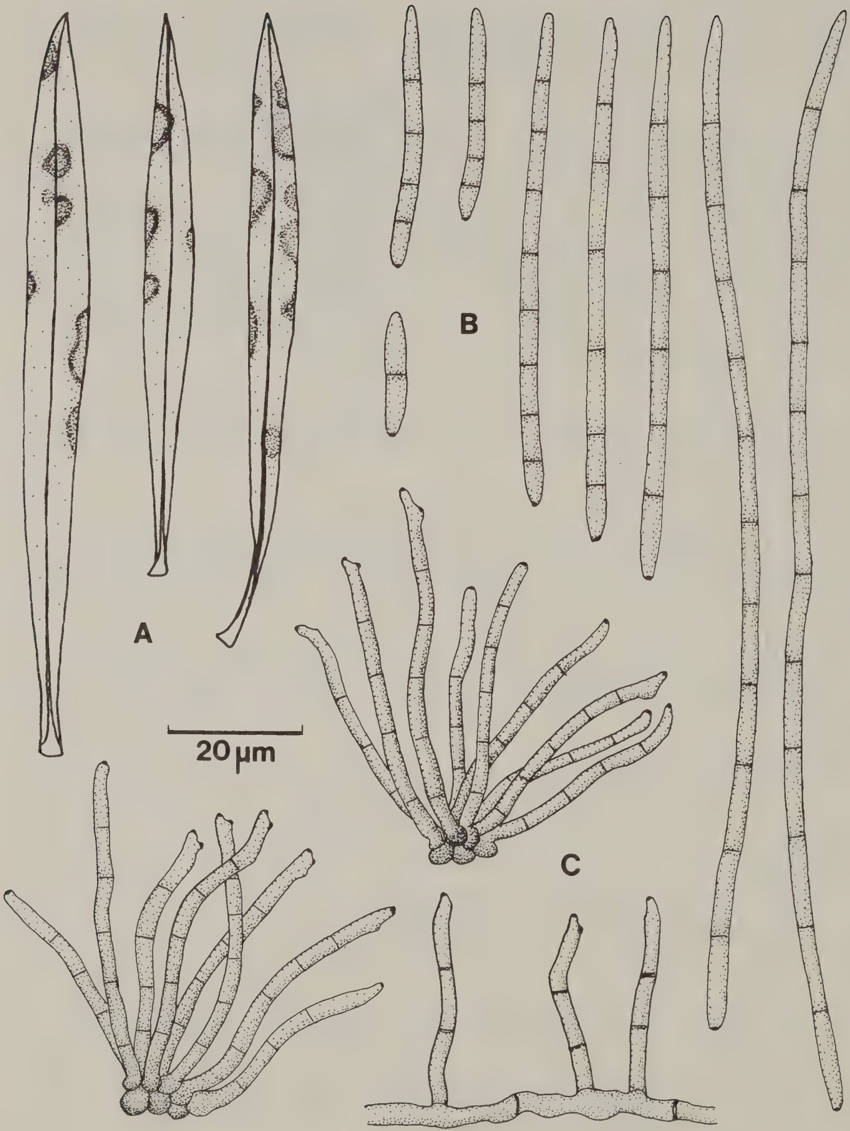

Fig. 4. *Stenella dianthi* : A, Hypophyllous leaf spots; B, Conidia; C, Conidiophores. H.D. Shin del.

rium immersum. Stromata substomatalia, saepe hypophylla, parva vel bene evoluta, subglobosa vel leniter irregulares, atrobrunnea, ca. 15-30(-40) µm diam. Mycelium secundarium superficiale: hyphae repentes, pallide olivaceo-brunneae, ca. 1-2(-3) µm diam., minute verruculosae, sed sub et prope conidiophora secundaria leaves, satiore brunneae et leniter latiores. Conidiophora fasciculata (-20), divergentia vel solitaria, ex hyphis mycelialibus secundariis lateraliter producta, cylindrica, modice vel atro-brunnea, interdum apicem versus pallidiora, erecta, non ramosa, 0-2(-3) septata (conidiophora hypophylla) vel (2-)4-9 septata (conidiophora epiphylla), 45-90 x 2.5-3.5 µm. Cicatrices conidiales conspicuae, minutae, incrassatae. Conidia solitaria, 16-153 x 2-3.5 µm, subcylindrica vel cylindro-obclavata, recta vel leniter curvata, subhyalina vel pallide olivaceo-brunnea, 1-14 septata, non constricta, minute verruculosa vel sublaevia, apice subobtusa, basi subtruncata, hila minuta, leniter incrassata et obscura.

Leaf spots amphigenous, orbicular, 1-3 mm diam., pale tan to brown, with dark reddish brown margin. Caespituli amphigenous. Primary mycelium internal, forming substomatal stromata, especially hypophyllously, stromata almost absent to well developed, subglobose or somewhat irregular, dark brown, ca 10-30(-40) µm diam. Secondary mycelium external: creeping hyphae very pale olivaceous brown, ca. 1-2(-3) µm diam., finely verruculose; hyphae with lateral secondary conidiophores smooth, dark brown and somewhat wider (2-3 µm). Conidiophores up to 20 in a divergent fascicle or solitary, formed on external hyphae, cylindric, medium to dark brown, uniform in colour and width or paler to subhyaline at the apex, straight, not branched, 0-2(-3)-septate in epiphyllous conidiophores, but (2-)4-9-septate in hypophyllous ones, 45-90 x 2.5-3.5 µm, conidial scars conspicuous, small, thickened. Conidia solitary, 16-153 x 2-3.5 µm, subcylindric to cylindric-obclavate, straight or slightly curved in longer conidia, subhyaline to pale olivaceous brown, 1-14-septate, not constricted, shorter conidia finely verruculose, longer ones smooth or almost so, apex subobtuse, base subtruncate, hila small, slightly thickened and darkened.

Holotypus: On *Dianthus sinensis* L. (Caryophyllaceae), Kangnung, Korea, 28 VIII 1991, Shin (Herbarium, Department of Horticulture, Kangnung National University).
Isotypus: HAL.

Comparable *Stenella* species on *Dianthus* and allied host genera are unknown.

## ACKNOWLEDGEMENTS

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# Morphological Differences between the Conidial States of Erysiphe cichoracearum and E. valerianae

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## 줄 인 글

마타리과 식물의 흰가루병균인 *Erysiphe valerianae* (Jacz.) Blumer가 주로 국화과 및 박과 식물의 흰가루병균인 *E. cichoracearum* DC.로 부터 분리되어 독립된 종으로 인정받아 왔으나, 두 종간의 뚜렷한 형태적 차이가 없어 폐기명으로 취급되기도 하였다. 그러나 *E. valerianae*의 무성세대를 검경한 결과, 지금까지 알려지지 않았던 분류특성들을 찾아냈으며 *E. cichoracearum*과 구별되는 분류특성들을 기록하였다. 특히 이 종은 분생자경이 모세포의 측면에서 발생하여 L자형의 기부세포를 가지므로 직선형의 기부세포를 갖는 *E. cichoracearum*과 뚜렷이 구별되었다. 따라서 *E. valerianae*는 유성세대 뿐만 아니라 무성세대에서도 *E. cichoracearum*과 분류학적 특징이 다르므로 보존명으로 취급되어야 한다.

*Erysiphe valerianae* (Jacz.) Blumer is close to *E. cichoracearum* DC. in phylogenic relationship (Blumer, 1933) and also in morphological characteristics of both anamorph and teleomorph (Blumer, 1967; Junell,1967; Braun,1981). The differences in the teleomorphic states of these two species were studied in the morphology of perithecial appendages and perithecial wall-cells (Junell, 1967; Zheng & Chen, 1981; Salata, 1985; Braun, 1987). But, the problem of how to distinguish them in their conidial states has been encountered on *Valeriana* spp. and *Patrinia* spp. by many workers (Braun, 1981; Zheng & Chen, 1987; Shin, 1990, unpublished). Therefore, in most papers the conidial collections of powdery mildew fungi from Valerianaceous hosts have been treated as *E. cichoracearum* (Amano,1986).

Since Blumer(1933) treated the powdery mildew fungus on *Valeriana* spp. as the new species *E. valerianae*, most authors (Junell, 1967; Boesewinkel, 1980; Sz. Nagy, 1976, 1980; Zheng & Chen, 1981; Salata, 1985) accepted his specific delimitation and treated it different from *E. cichoracearum*. On the other hand, Braun had regarded *E. valerianae* as a synonym of *E. cichoracearum* (1981), but later treated this species different from *E. cichoracearum* by its rather wide and usually obviously verrucose appendages (1987).

According to Blumer's original description (1933) and his revised monograph (1967), conidia of *E. valerianae* are generally longer than those of *E. cichoracearum*, and thus length/breadth (l/b) ratio of the former is mostly more than 2 and that of the latter generally less than 2. Similar size values and l/b ratios of conidial measurements were described by Junell (1967). The other morphological characteristics of taxonomic value in conidial state were unknown, but treated as similar to or even the same as in *E. cichoracearum* (Boesewinkel, 1980).

As reviewed by Boesewinkel(1980) and pointed out by Yarwood(1978) and Shin (1992), however, the size measurements and l/b ratio of conidia should not be emphasized. As an example, measuring the conidia of 40 collections of *E. cichoracearum* from different species of host plants, Sz. Nagy (1976) found l/b ratios of conidia ranging from 1.71 to 2.23 even in their mean values. Shin (1988) also gave the mean value of l/b ratio in conidia of *E. cichoracearum* as 1.33 to 2.06 measured from 13 different species of host plants. Therefore, the simple difference in size value and l/b ratio of conidia between the above two species is not enough to distinguish them from each other.

In the meanwhile, the author collected the anamorphic state of a powdery mildew fungus on *Patrinia scabiosaefOlia* and *P. villosa*, members of Valerianaceae, at several locations in Korea during 1990-1992. Morphological characteristics of these collections were always different from those of *E. cichoracearum*, which is recorded on *Patrinia* spp. in Japan, China, and the Far East of Russia (Amano, 1986). Conidia were produced in chains on the conidiophores with sinuate edge and the foot-cell of conidiophore arised from the side of a mycelial hypha, the basal part being curved (Fig. 1). This fungus was rather close to *E. sordida* in the sense of having curved foot-cells of conidiophores and to *E. valerianae* in size value of conidia and host family. Therefore, it was tried to compare this fungus with *E. valerianae* previously recorded in Europe on Valerianaceae. No powdery mildew fungus has been collected from *Valeriana* spp. in Korea.

The author examined the anamorphic characteristics from two specimens of *E. valerianae* provided by Dr. Salata from Poland. Though the general morphology of the fungus was close to *E. cichoracearum*, the foot-cell of conidiophore arised from the side of a mycelial hypha, the basal part being curved. On the other hand, as well-known in earlier literature (Boesewinkel, 1980; Shin, 1988), the foot-cell of conidiophore in *E. cichoracearum* is straight. In addition, Dr. Y. Nomura provided me a herbarium specimen (YNMH 8039) of *Oidium* sp. from *Valeriana flaccidissima*, which was the same as the anamorph of *E. valerianae* in morphological characteristics. Recently, Dr. Nomura sent me a draft drawing of *Oidium* sp. on *Valeriana flaccidissima* (YNMH 9343), which was also the same as the anamorph of *E. valerianae*. Therefore, these two species should be treated as separate ones (Table 1) and *E. valerianae* be maintained.

Because most of the anamorphic characteristics of taxonomic value found in *E. valerianae* have not been reported, the conidial state of

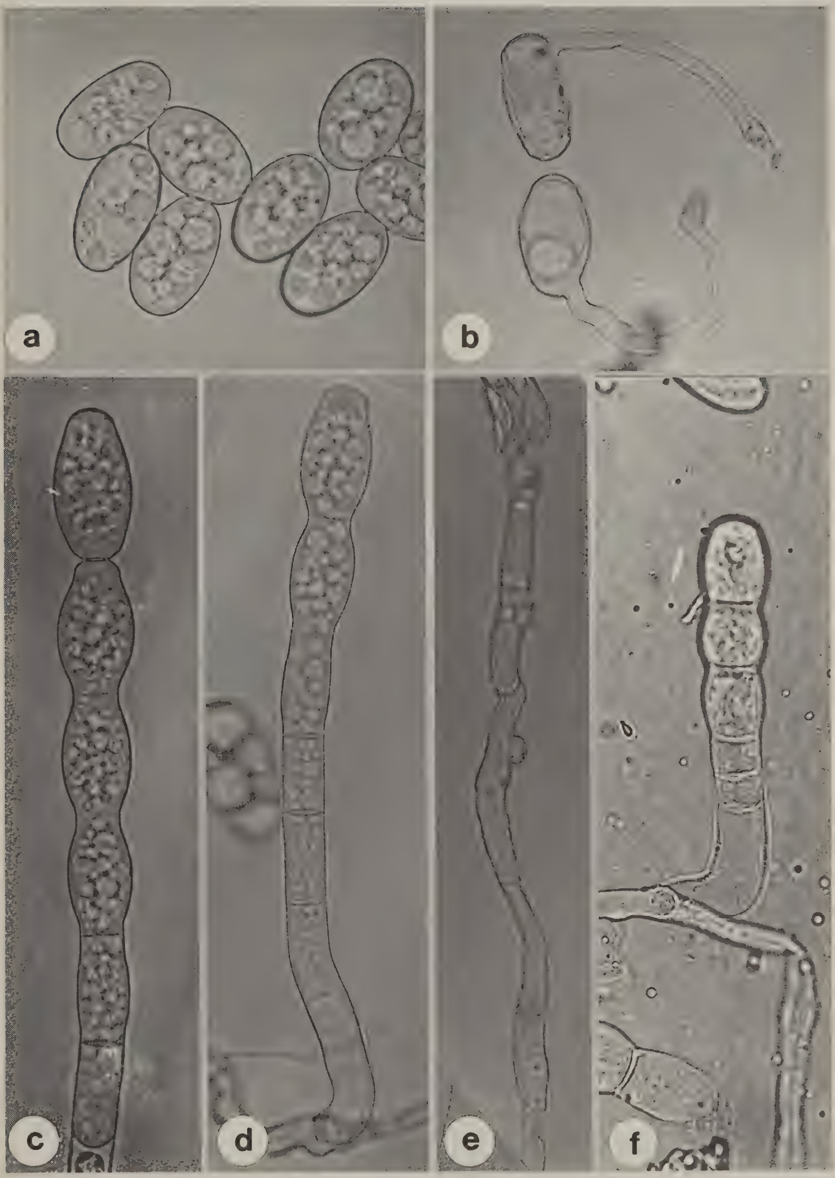

Fig. 1. *Erysiphe valerianae* (Jacz.) Blumer examined from *Patrinia scabiosaefolia* (ⓐ–ⓔ) and *Valeriana officinalis* (ⓕ). ⓐ conidia, ⓑ conidia in germination, ⓒ the upper part of conidiophore with sinuate edge, ⓓ conidiophore with curved foot-cell, ⓔ mycelium with nipple-shaped appressorium, ⓕ conidiophore with curved foot-cell. Dried material (ⓕ) was restored by heating in lactic acid.

the present fungus based on the author's fresh material (SMK 10407) from *Patrinia scabiosaefolia* is described as follows:

***Oidium*** **state of** ***Erysiphe valerianae*** (Jacz.) Blumer

Amphigenous, occasionally cauligenous; mycelium generally thin, but well developed on the upper part of leaves in the shade, forming thinly effused white film, branching at right angle, straight, 26-63 x 4.5-6.7 µm; appressoria nipple-shaped, single; conidiophores 79-234 x 10.8-12.2 µm, curved in foot-cells, producing conidia in chains with sinuate edge line, followed by (1-) 2-3 straight cells, basal septum at the branching point; conidia ellipsoidal to cylindric oval, 27.0-38.7 x 15.3-22.5 µm (length/breadth = 1.30-2.46), without conspicuous fibrosin bodies, producing germ tubes on the end.

Specimens examined: SMK 10407, 10420, 10615, 10754, 10821, 10964, 11088, 11267, 11268, 11271, 11469, 11502, 11698. (SMK = Herbarium, Department of Horticulture, Kangnung National University, Korea).

Specimens compared: YNMH 8039, 9343. Dried materials collected from *Valeriana angustifolia* and *V. officinalis* in Poland, on Sep. 7, 1976 and Sep. 29, 1977, respectively, by Dr. B. Salata.

Table 1. Comparative morphological observations on the anamorphic characteristics of *Erysiphe cichoracearum* and *E. valerianae*.

| Characteristics | *E. cichoracearum* | *E. valerianae* |
|---|---|---|
| Mycelium | | |
| habitat | amphigenous, also cauligenous | amphigenous, also cauligenous |
| density | thin to thick | thin |
| branching | at right angle | at right angle |
| appressoria | nipple-shaped | nipple-shaped |
| length (µm) | 38-84 | 26-63 |
| diameter (µm) | 3.6-5.2 | 4.5-6.7 |
| Conidiophores | | |
| conidia production | in chains | in chains |
| edge line | sinuate | sinuate |
| measurements (µm) | 99-225 x 10.4-12.5 | 79-234 x 10.8-12.2 |
| foot-cells | **straight** | **curved** |
| basal septum | at branching point | at branching point |
| Conidia | | |
| measurements (µm) | 26-42 x 16-23 | 27-39 x 15-23 |
| l/b ratio | 1.33-2.06 | 1.30-2.46 |
| shape | ellipsoidal to oval | ellipsoidal to cylindric oval |
| fibrosin bodies | absent | absent |
| Germ tubes | | |
| shape | long, straight | long, straight |
| position | at end of conidia | at end of conidia |

## ACKNOWLEDGEMENTS

Thanks are due to Dr. Y. Nomura, Japan, for providing a herbarium specimen and an unpublished information on the morphological characteristics of *Oidium* sp. from Japanese *Valeriana* sp. and to Dr. B. Salata, Poland, for providing two herbarium specimens. Appreciation is extended to Dr. U. Braun, Germany, for invaluable discussion and critical review of the manuscript.

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# STUDIES ON WOOD-ROTTING BASIDIOMYCETES OF HAWAII

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## SUMMARY

Collections of wood-rotting basidiomycetes on the islands of Maui and Hawaii in 1990 included 60 species, 46 of which were previously unreported from the State of Hawaii. *Athelia bambusae*, *Hyphoderma crystallophorum*, *H. vulcanense*, *Hyphodontia aloha*, *Lachnella conferta*, *Phanerochaete mauiensis*, *Phlebiopsis peniophoroides*, and *Sirobasidium sandwicense* are described as new.

In June, 1990 the authors made 150 collections of wood-rotting fungi from woody angiosperms on the islands of Maui and Hawaii, State of Hawaii. On Maui, most of the collections were made along the Hana Highway on the east side of the island. On the island of Hawaii, most of the collections were made in forested areas in the eastern portion from Hilo to Hawaiian Volcanoes National Park (hereafter abbreviated as HVNP) and along the southeastern coast. On both islands, these are areas of high annual rainfall with extensive forest ecosystems with many native and naturalized exotic species of trees and smaller woody plants. The high annual rainfall (up to 355 cm per year) and the year-round moderate temperatures, combined with the abundance of woody substrates, makes this an ideal location for the study of wood-rotting fungi.

Microscopic characters were determined from free-hand sections or squashed mounts in KOH, phloxine, and in Melzer's reagent. Drawings were made with the aid of a camera lucida on a Leitz Labolux microscope. Capitalized color names are from Ridgway (1912). Specimens are deposited in the Mycological Herbarium, University of Arizona. Author abbreviations of fungal names follow Kirk and Ansell (1992). Common names and authorities of plant species reported as substrates in this paper are provided after our annotated list of fungal species.

## ANNOTATED LIST OF SPECIES

*ANTRODIA SINUOSA* (Fr.) P. Karst.

**Basidiocarps** resupinate, annual, becoming effused up to 20 cm or more, adherent, margin abrupt to thinning out, then narrowly sterile up to 1.5 mm, Cream Color to Light Buff; pore surface drying to Buffy Brown, the pores angular, 3-5 per mm, dissepiments thin, entire; subiculum Cream Color to Cartridge Buff or Light Buff, soft-fibrous, less than 1 mm thick; tube layer Isabella Color, up to 4 mm thick.
**Hyphal system** dimitic; subicular generative hyphae hyaline, thin-walled, with clamps, 2.5-3.5 μm in diam; contextual skeletal hyphae hyaline, thick-walled, nonseptate, rarely branched, 2.5-4 μm in diam; tramal hyphae similar.
**Cystidia** absent, fusoid cystidioles present.
**Basidia** clavate, 4-sterigmate, small, 10-15 x 4-5 μm, with a basal clamp.
**Basidiospores** cylindric to allantoid, hyaline, smooth, negative in Melzer's reagent, 4.5-5.5 x 1.5-2 μm.
JEA 1476, 1502, Bird Park, HVNP, associated with a brown cubical rot of dead, fallen *Metrosideros polymorpha* (ohia lehua). Cream colored mycelial felts are present in the shrinkage cracks in the brown-rotted wood. Some parts of the basidiocarps were heavily parasitized by *Calcarisporium arbuscula* Preuss.
Cunningham (1947, 1965) reports a similar fungus, *Poria rata* G.H. Cunn. on *Metrosideros robusta* in New Zealand, stating that it is associated with a brown rot. *Poria rata* differs from *A. sinuosa* in having ellipsoid to ovoid or pip-shaped spores.

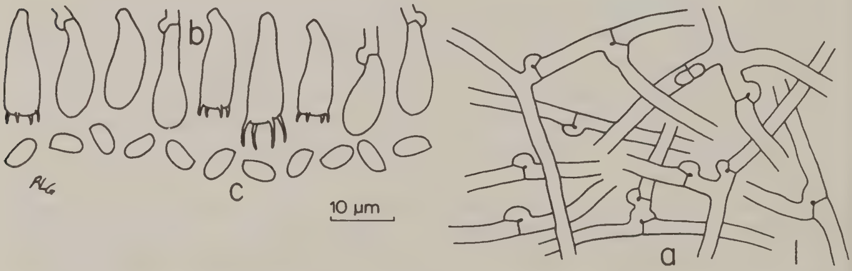

Fig. 1. *Athelia bambusae* (RLG 16797). a, subicular hyphae; b, basidia; c, basidiospores.

*ATHELIA BAMBUSAE* Gilb. & Adask., sp. nov. Fig. 1

*Fructificatio annua, resupinata, textura lenis et facile disjuncta; superficies hymenii cremei; subiculum exile et fragile; systema hypharum monomiticum, hyphae nodoso-septatae, 2-4 μm diam; basidia late clavata, 4-sterigmatica, 11.5-13 X 5.5-7.0 μm; basidiosporae oblongae ad brevi-columnares, hyalinae, 5-6 X 2.5-3 μm. Holotypus: RLG 16797 (BPI). In calamis mortuis Bambusae vulgaris Schrad.*
**Etymology**: On *Bambusa* (bamboo).

**Basidiocarps** annual, resupinate, effused up to 6 cm, soft, pelliculose and easily separated; hymenial surface cream-colored, smooth; margin thinning out; subiculum thin, fragile.
**Hyphal system** monomitic; subicular hyphae hyaline, thin-walled, with clamps at all septa, frequently branched, 2-4 μm in diam.
**Cystidia** or other sterile hymenial elements absent.
**Basidia** broadly clavate, 4-sterigmate, 11.5-13 x 5.5-7, with a basal clamp.
**Basidiospores** oblong to short-cylindric, hyaline, smooth, 5-6 x 2.5-3 μm, negative in Melzer's reagent.
RLG 16797, Mile 8, Hana Highway, Maui, on dead, fallen stems of *Bambusa vulgaris* Schrad., associated rot not discernible.

*BOURDOTIA ASPERA* (L.S. Olive) K. Wells, Mycologia 51:550. 1959.

**Basidiocarps** annual, resupinate, effused up to 10 cm, appearing as an arid, inconspicuous, thin film; hymenial surface smooth, discontinuous and porose under a 30X lens, grayish tan (Drab-Gray), margin thinning out; subiculum less than 100 μm thick.
**Hyphal system** monomitic; hyphae difficult to discern, agglutinated and gelatinizing in subiculum and subhymenium, apparently without clamps, 1.5-2 μm in diam.
**Gloeocystidia** abundant, cylindric to fusoid, often contorted, thin-walled, some containing golden brown, globular material, others appearing empty, up to 60 mm long, 5-10 μm in diam.
**Basidia** globose to ellipsoid, becoming cruciately septate at maturity, 14-20 x 10-14 μm, sterigmata slender, up to 15 μm long, 1-2 μm in diam.
**Basidiospores** globose, hyaline, minutely echinulate to verrucose at maturity, negative in Melzer's reagent, 7.5-10 μm in diam.
RLG 16785, Mile 6, Hana Highway, Maui, associated with a white rot of dead, fallen *Eugenia jambos* L. (rose apple or ohia loke).
This specimen differs from descriptions of *B. aspera* given by Olive (1958) and Wells (1959) in having considerably smaller spores. Spores of *B. aspera* are described by those authors as being 12.5-18 μm in diam.

*CERIPORIA EXCELSA* (S. Lundell) Parmasto. RLG 16823, Bird Park, HVNP, Hawaii, causing a white rot of dead *Metrosideros polymorpha* Gaud. (ohia lehua).

*CHAETOPORELLUS LATITANS* (Bourdot & Galzin) Bondartzer & Singer. JEA 1481, 1486, Bird Park, HVNP, Hawaii, causing a white rot of dead, fallen *Metrosideros polymorpha*.

*CRYPTOTRAMA ASPRATA* (Berk.) Redhead & Ginns. RLG 16837, Highway 137, Opihikao, Hawaii, on dead *Terminalia catappa*, associated with a white rot. The spores are small (about 8 x 6 μm) but in the range given by Redhead and Ginns (1980) for this species. They cite a Hawaiian specimen from Oahu and state that it also had small spores.

*DACRYMYCES DELIQUESCENS* (Mérat) Duby var. *DELIQUESCENS*. RLG 16779, Mile 6, Hana Highway, Maui, on basidiocarps of *Hymenochaete anomala* Burt on dead, fallen *Eugenia jambos*, also fruiting on wood surface adjacent to the *Hymenochaete*, underlying wood with a white rot caused by the *Hymenochaete* and a brown rot presumably caused by the *Dacrymyces*. Spores 3-septate at maturity, 12-15.5 x 5-6 μm, internal hyphae smooth, septate, clamps absent. According to Kennedy (1958) these characters match those of *D. deliquescens*.

*EARLIELLA SCABROSA* (Pers.) Gilb. & Ryvarden. RLG 16811, Keanae Arboretum, Hana Highway, Maui, causing a white rot of fallen hardwood.
Reported from Hawaii by Cunningham (1965). This is a widely distributed species in the American neotropics and occurs in the Gulf Coast region of the USA (Gilbertson and Ryvarden 1986).

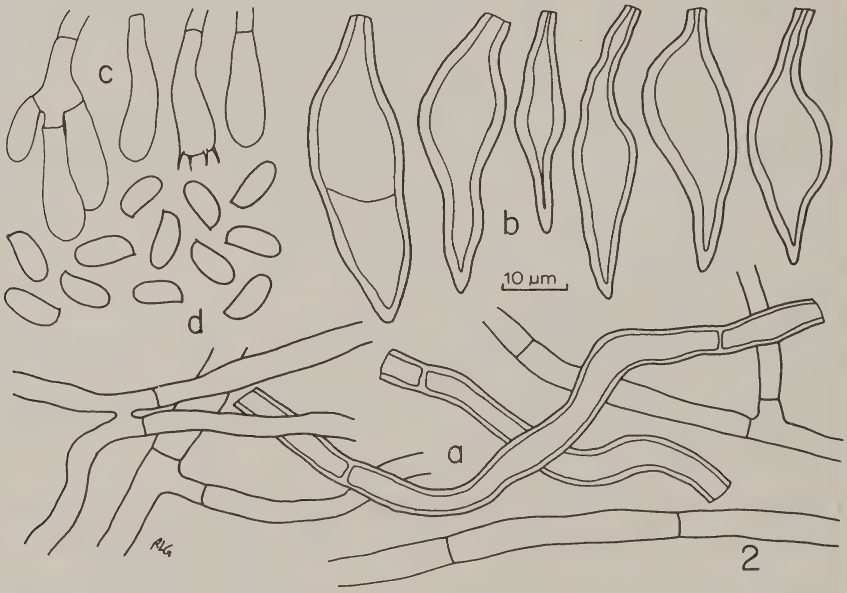

Fig. 2. *Flavodon cervino-gilvus* (RLG 16845). a, contextual generative hyphae; b, cystidia; c, basidia; d, basidiospores.

*FLAVODON CERVINO-GILVUS* (Jungh.) Corner Fig. 2

**Basidiocarps** annual, resupinate to effused-reflexed, effused up to 20 cm, reflexed up to 3 cm; pilear surface reported to be yellowish when fresh, drying light brown, soft and spongy, smooth to scrupose, margin acute, becoming reflexed on drying; pore surface light brown, the pores angular and appearing hexagonal, 2-3 per mm, dissepiments thin, entire; context light brown, soft, azonate, up to 2.5 mm thick; tube layer concolorous and continuous with context, up to 3 mm thick.

**Hyphal system** monomitic; contextual hyphae simple-septate, thin- to moderately thick-walled, hyaline to pale greenish brown in mass in KOH, with occasional branching, 2.5-5 μm in diam; tramal hyphae similar.

**Cystidia** scattered in hymenium and imbedded in subhymenial tramal tissue, becoming thick-walled, ventricose, hyaline in KOH, tapering to a narrow or rounded tip, 30-50 x 10-15 μm.

**Basidia** in candelabrums from branching subhymenial hyphae, clavate, 4-sterigmate, 15-23 x 5.5-6 μm, simple-septate at the base.

**Basidiospores** cylindric, slightly bent at the base, hyaline, smooth, thin-walled, negative in Melzer's reagent, 7-9.5 x 3.5-4 μm.

RLG 16845, MacKenzie Park, Highway 137, Hawaii, on *Casaurina equisetifolia* L. (ironwood); JEA 1496, ravine behind Hemmes residence, Hilo, Hawaii, on *Trema orientalis* (L.) Blume (gunpowder tree or charcoal tree); causing a white rot.

This is the first report of *F. cervino-gilvus* from the USA. It is readily distinguished in the field by the pale brown color of the pilear and pore surfaces, large, angular pores, and the soft, scrupose pilear surface. Microscopically, the simple-septate hyphae and thick-walled cystidia are diagnostic features.

*FOMITOPSIS NIVOSA* (Berk.) Gilb. & Ryvarden. RLG 16865, RLG 16867A, in ravine behind Hemmes residence, Hilo, Hawaii, on dead *Trema orientalis*, causing a brown rot. This taxon is apparently cosmopolitan in tropical and subtropical regions of the world and occurs in the Gulf Coast region of the USA.

*HAPLOTRICHUM CURTISII* (Berk.) Hol.-Jech. Fig. 3

RLG 16827, on dead, fallen ohia lehua, Bird Park, HVNP, associated with a white rot. Colonies effused up to several cm, loosely floccose to wooly, Sayal Brown to Tawny; conidiophores simple-septate, spirally twisted, slightly pigmented, pale brownish, 6-9 μm in diam, with swollen conidiogenous vesicles developing apically or laterally on subterminal cells; vesicles up to 14 μm in diam; conidia produced on short, stout denticles that are up to 3 μm in diam and 2.5 mm long, conidia spherical, hyaline to weakly pigmented and pale brownish, smooth or appearing minutely punctuate because of pitted endospore, 11-18 μm in diam, negative in Melzer's reagent. This is the anamorph of *Botryobasidium vagum* (Berk. & Curt.) D.P. Rogers. Linder (1942) lists a collection of this fungus from Hawaii.

*HOHENBUEHELIA APPROXIMANS* (Peck) Singer. RLG 16813, Kapuaa Park, Hawi Highway, Hawaii, on bark of living *Prosopis pallida* (Humb. & Bonpl. ex Willd.) H.B.K. A prolonged search for wood-rotting fungi on the dead branches of larger mesquite trees in this arid locality produced only this collection of *H. approximans* and one of *Phanerochaete flavido-alba*. The distinctive complex of species reported on dead branches of mesquite in Arizona (Gilbertson et al. 1976) was completely absent.

*HYMENOCHAETE ANOMALA* Burt. RLG 16777, Mile 6, Hana Highway, Maui, on dead, fallen branches of *Eugenia jambos*, causing a white rot. Characterized by relatively short setae up to 45 μm long and small spores about 3.5-1.5 μm.

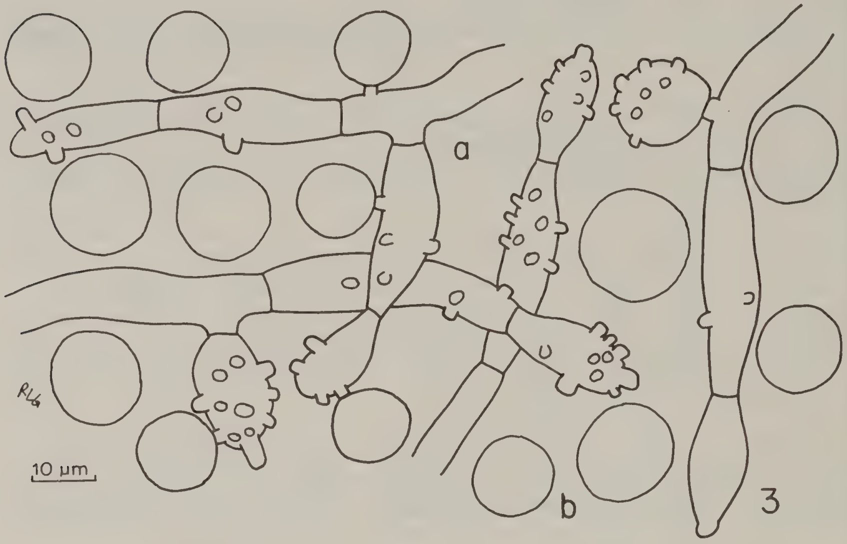

Fig. 3. *Haplotrichum curtisii* (RLG 16827). a, hyphae with conidiogenous cells; b, conidia.

*HYMENOCHAETE CORRUGATA* (Fr.) Lév. JEA 1499, Hana Highway, Maui, on dead *Spathodea campanulata*; RLG 16826, Bird Park, HVNP, Hawaii, on dead, fallen *Sapindus saponaria* L. (wingleaf soapberry), causing a white rot. Characterized by resupinate basidiocarps that crack extensively into small angular blocks on drying, large setae up to 150 μm long, and narrow, cylindric spores 6-7 x 2-2.5 μm.

*HYPHODERMA CRYSTALLOPHORUM* Gilb. & Adask., sp. nov. Fig. 4

*Fructificatio annua, resupinata; textura lenis et facile disjuncta; superficies hymenii albi ad cremeum, denticulatam (aculeatam), aculei cylindrici ad deplanatos cum apicibus ad adparenter saccharatis; systema hypharum monomiticum, hyphae subiculi crassitunicati, nodoso-septatae, 2-4 um diam; cystidia abundantia, immersa, ventricosa (20-30 X 12-13 μm) ad cylindrica (50-80 X 8-10 μm), cum vel sine aliquo refringenti, quod intus continetur, saepe cum minuta spina apicali; stephanocystides infrequentes 10-11 μm; basidia clavata, 20-24 X 6-7 μm; basidiosporae cylindrico-ellipsoidae, exigue curvatae, 7.5-9 X 4-4.5 μm. Holotypus: RLG 16791 (BPI). In Hibisco tiliaceo.*
**Etymology**: Bearing crystals (referring to apices of aculei).

**Basidiocarps** annual, resupinate, effused up to 20 cm, soft, easily separated; hymenial surface white to Cream Color, hydnaceous with small, cylindric to flattened aculei with minutely fimbriate, sugary looking apices, scattered and separated by smooth hymenial surface; margin thinning out; subiculum soft, white, very thin; aculei with hymenium on basal portion, mostly heavily incrusted with large, coarse crystals over an obscure core of interwoven hyphae.

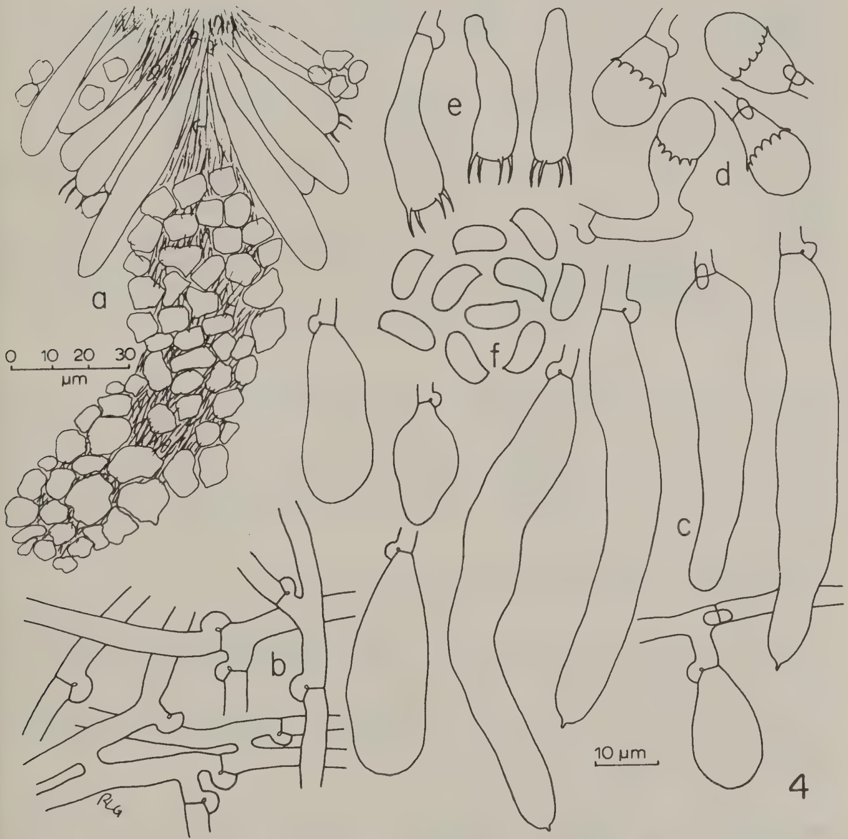

Fig. 4. *Hyphoderma crystallophorum* (RLG 16791). a, schematic drawing of incrusted tooth; b, subicular hyphae; c, gloeocystidia; d, stephanocysts; e, basidia; f, basidiospores.

**Hyphal system** monomitic, subicular hyphae hyaline, with clamps at all septa, with frequent branching, 2-4 μm in diam, thick-walled in the basal subiculum, thin-walled in the subhymenium.

**Cystidia** abundant, imbedded in subhymenium and subiculum and in hymenium, thin-walled, with a basal clamp, ranging from short and ventricose (20-30 x 12-13 μm) to elongated and cylindric (50-80 x 8-10 μm), some with highly refractive contents that stain brightly in KOH and phloxine, others hyaline, without refractive contents and not staining in KOH and phloxine, often with a small apical spine.

**Stephanocysts** infrequent but present in all sections, with a refractive, globular apical cell delimited by a septum with a toothed fringe, with a clamp on the narrowed base, apical cell 10-11 μm in diam.

**Basidia** clavate, 4-sterigmate, 20-24 x 6-7 μm, with a basal clamp.

**Basidiospores** cylindric-ellipsoid, slightly curved, hyaline, smooth, thin-walled, negative in Melzer's reagent, 7.5-9 x 4-4.5 μm.

RLG 16791, Mile 6, Hana Highway, Maui, on *Hibiscus tiliaceus*, associated with a white rot.

This taxon is in the *Hyphoderma praetermissum* complex and is distinct morphologically because of its hydnaceous hymenophore with the aculei heavily incrusted with coarse crystals. *Hyphoderma crystallophorum* is similar to *H. rude* (Bres.) Hjortstam & Ryvarden from Brazil as described by Hjortstam and Ryvarden (1980). The aculei of the latter are not incrusted, and it has wider, more ellipsoid spores.

*HYPHODERMA PRAETERMISSUM* (P. Karst.) J. Erikss. & Å. Strid. JEA 1472, Keanae Arboretum, Hana Highway, Maui, on dead, fallen branches of *Hibiscus tiliaceus* L. (hau); RLG 16780, Mile 6, Hana Highway, Maui, on dead *Eugenia jambos*; RLG 16870, in ravine behind Hemmes residence, Hilo, Hawaii, on *Trema orientalis*, causing a white rot. These specimens have a smooth hymenophore and fit well into the traditional concept of this species.

*HYPHODERMA VULCANENSE* Gilb. & Adask., sp. nov. Fig. 5

*Fructificatio annua, resupinata; superficies hymenii albi ad luteum; systema hypharum monomiticum, hyphae nodoso-septatae, 2-4 μm diam; cystidia infrequentia cylindrica, tenuitunicatae, 45-50 X 7-8 μm; basidia clavata et angusta, cum 4-sterigmatica, 25-30 X 4-5 μm; basidiosporae cylindricae, suballantoidae, 6.5-8 X 2-2.5 μm. Holotypus: RLG 16832 (BPI). In Terminalia catappa L.*

**Etymology**: Of volcanic regions.

**Basidiocarps** annual, resupinate, effused up to 10 cm, adherent; hymenial surface Cream-Buff to Warm-Buff, smooth to distinctly tuberculate, developing small cracks on drying, revealing a loose, white subiculum; margin rather abrupt, with a narrow zone of sterile white mycelium in places.

**Hyphal system** monomitic; subicular hyphae thin-walled, hyaline, with clamps, with frequent branching, often in H-shaped configurations, 3-5 μm in diam.

**Cystidia** scattered or in small groups, cylindric, usually tapering slightly toward the apex, thin-walled, not incrusted, 45-50 x 7-8 μm.

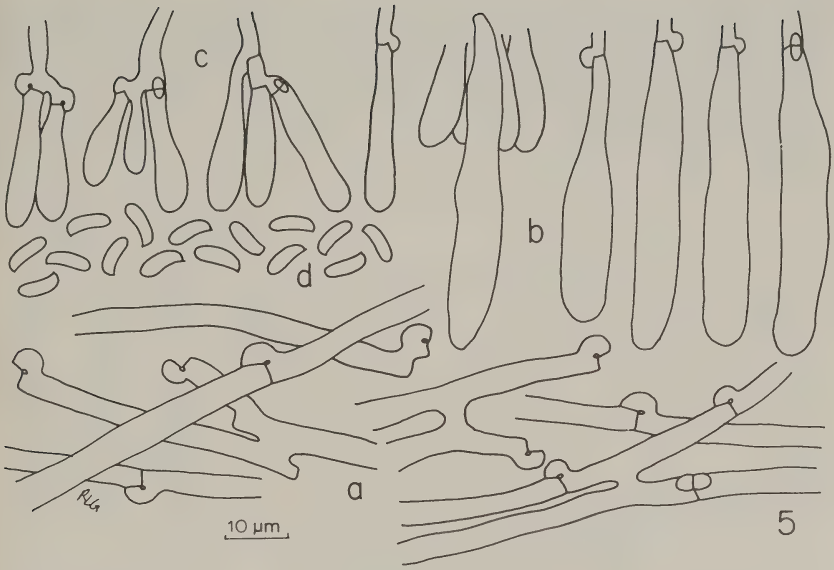

Fig. 5. *Hyphoderma vulcanense* (RLG 16855A). a, subicular hyphae; b, cystidia; c, basidia; d, basidiospores.

**Basidia** narrowly clavate, 4-sterigmate, 25-30 x 4.5-5.5 µm, with a basal clamp.
**Basidiospores** cylindric, suballantoid, hyaline, smooth, thin-walled, negative in Melzer's reagent, 6.5-8 x 2-2.5 µm.
RLG 16832, RLG 16833, near the Kiluaea lava flow, Opihikao, Highway 137, Hawaii, on dead *Terminalia catappa* L.; RLG 16855A, Baptist Church, Hilo, Hawaii, on dead *Trema orientalis*; associated with a white rot.
The distinctive hyphal structure, cylindric, nonincrusted cystidia, and the suballantoid basidiospores characterize this species.

*HYPHODONTIA ALOHA* Gilb. & Adask., sp. nov. Fig. 6

*Fructificatio annua, resupinati, haesi at molles, fragiles; superficies hymenii ravidi, albi ad luteum, odontoidei, aculei parvi, solitari ad confluentos cum apicibus fimbriatis; systema hypharum dimiticum, hyphae generatores nodoso-septatae, 3-4 µm diam; hyphae subhymenii cum apophyse irregulare; hyphae skeletales crassitunicatae, nonseptatae, 3-4 µm diam; cystidia hyphoida, tenuitunicata, nonincrusta, 3-5 µm diam, usque ad 60 µm longa, in fasciculo in aculeo apicibus; basidia cum colligatio medio, 4-sterigmatica, 8-12 X 4-4.5 µm; basidiosporae ovoidae ad ellipsoideo, 3-4 X 2-3 µm. Holotypus: RLG 16806A (BPI). In calamis mortuis Hibisco tiliaceo.*
**Etymology**: Hawaiian word of greeting.

**Basidiocarps** annual, resupinate, effused up to 20 cm, adherent but soft, fragile, and easily separated; hymenial surface grayish-white to Pale Olive-Buff, odontoid with small, single to confluent aculei with minutely fimbriate apices, aculei or small groups of aculei separated by flat, smooth areas showing the loosely interwoven subiculum, aculei and subiculum soft and easily picked or scraped from substratum; subiculum white, very thin, arachnoid.

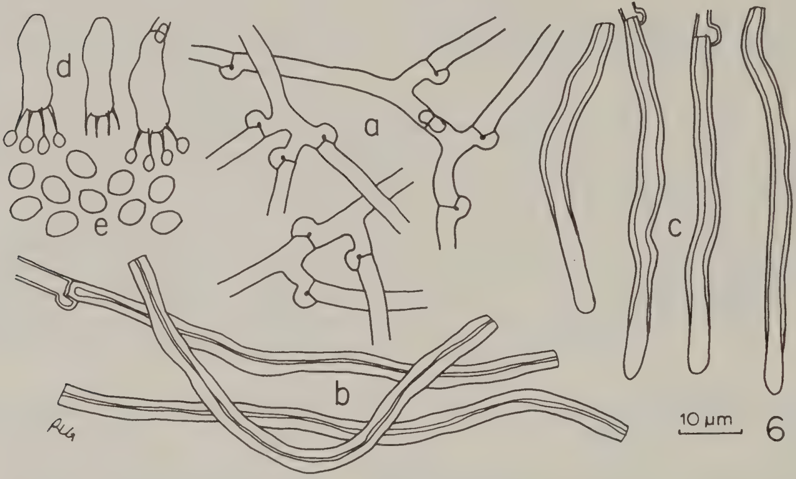

Fig. 6. *Hyphodontia aloha* (RLG 16806A). a, subicular generative hyphae; b. subicular skeletal hyphae; c, cystidia; d, basidia; e, basidiospores.

**Hyphal system** dimitic; generative hyphae firm-walled, hyaline, with abundant and conspicuous clamps, frequently branched, 3-4 $\mu$m in diam, uniform in the subiculum but with irregular swellings in the subhymenium; skeletal hyphae thick-walled, with some appearing solid, hyaline, nonseptate, rarely branched, 3-4 $\mu$m in diam.

**Cystidia** hyphoid, in fascicles at the apices of aculei, thin- to firm-walled, 3-5 $\mu$m in diam, up to 60 $\mu$m long, not incrusted; cystidia absent in hymenium.

**Basidia** with a median constriction and a slightly swollen base, 4-sterigmate, 8-12 x 4-4.5 $\mu$m, with a basal clamp.

**Basidiospores** ovoid to ellipsoid, hyaline, smooth, thin-walled, negative in Melzer's reagent, 3-4 x 2-3 $\mu$m.

RLG 16806A, Keanae Arboretum, Hana Highway, Maui, on fallen branches of *Hibiscus tiliaceus*, associated with a white rot.

Species most similar to *H. aloha* are *H. aspera* (Fr.) J. Erikss. and *H. breviseta* (P. Karst.) J. Erikss. They differ from *H. aloha* in having capitate cystidioles and larger spores.

*HYPHODONTIA ARGUTA* (Fr.) J. Erikss. JEA 1479, Bird Park, HVNP, Hawaii, on dead *Metrosideros polymorpha;* RLG 16780A, on dead *Trema orientalis*, ravine behind Hemmes residence, Hilo; causing a white rot. This is a widely distributed taxon and is readily identified by its strongly hydnaceous hymenophore and lageniform cystidia.

*HYPOCHNICIUM PUNCTULATUM* (Cooke) J. Erikss. RLG 16783, Mile 6, Hana Highway, Maui, on dead *Eugenia jambos*, causing a white rot. The finely verrucose, subglobose basidiospores and cylindric, mostly imbedded cystidia are diagnostic characters of this species.

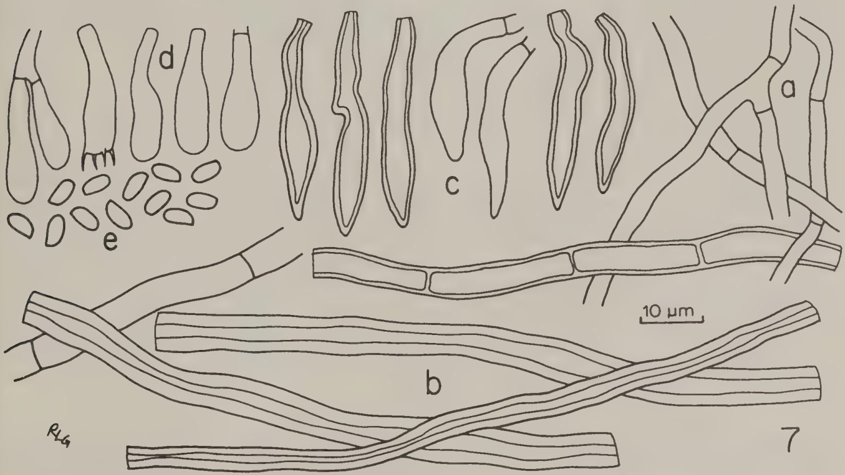

Fig. 7. *Irpex griseo-fuscescens* (RLG 16857). a, contextual generative hyphae; b, contextual skeletal hyphae; c, cystidia; d, basidia; e, basidiospores.

*IRPEX GRISEO-FUSCESCENS* (Reichardt) D.A. Reid, Kew Bull.17:273. 1963. Fig. 7

**Basidiocarps** annual, effused-reflexed to sessile, single or in imbricate clusters, individual pilei dimidiate to elongated, applanate, usually laterally confluent up to several cm; pilear surface matted-tomentose to almost glabrous near the base, shallowly concentrically sulcate and faintly zonate, Cream Color to Light Buff toward the margin, becoming grayish to Sepia near the base; margin thin and undulate; pore surface drying Tawny Olive to Olive-Brown, pores 2-3 per mm at the margin, dissepiments splitting just behind the margin to form a strongly hydnaceous hymenophore; context duplex, upper layer pale buff, up to 2 mm thick, soft-fibrous, lower layer more firm-fibrous, continuous and concolorous with trama; hymenophore up to 4 mm thick.

**Hyphal system** dimitic; contextual generative hyphae thin- to firm-walled, with frequent, often closely spaced simple septa, with occasional branching, 2-5 $\mu$m in diam; contextual skeletal hyphae thick-walled, nonseptate, rarely branched, 3-6 $\mu$m in diam;

tramal hyphae similar.

**Cystidia** abundant, subulate, hyaline, not incrusted, firm-walled, imbedded or projecting, 4-6 μm in diam, difficult to trace back to a basal septum, but commonly over 50 μm long.

**Basidia** clavate, 4-sterigmate, 17-20 x 4.5-5.5 μm, simple-septate at the base.

**Basidiospores** oblong, hyaline, smooth, thin-walled, negative in Melzer's reagent, 4-4.5 x 2-2.5 μm.

RLG 16857, Baptist Church, Hilo, Hawaii, causing a white rot of *Trema orientalis*. Cunningham (1965) described this fungus as *Trichaptum venustum* (Berk.) G.H. Cunn. Reid (1963) and Ryvarden and Johansen (1980), however, consider *T. venustum* to be a synonym of *T. byssogenum*, which is a quite different fungus with clamped generative hyphae, larger spores, and apically incrusted cystidia. Raabe et al. (1981) listed this fungus from Hawaii as *Polyporus vellereus* Berk.

*LACHNELLA CONFERTA* Gilb. & Adask., sp. nov. Fig. 8

*Fructificatio annua, disciforma ad cupulato, usque ad 1 mm diam, in tomentoso ad implico mycelio; epi-superficies albae, adparenter saccharatis; superficies hymenii alutacei ad brunneo cum exaridam; systema hypharum monomiticum; hyphae sub-basidiocarpi hyalini ad subfusco, tenuitunicatae, nodoso-septatae, 2.5-5 μm diam; cystidia fusiodea, tenuitunicata, hyalina (27-38 X 4.5-6 μm) ad subfusco (27-50 X 4.5-6 μm), basilare nodoso-septata cum aliquot incrusto; basidia anguste clavata, 4-sterigmatica, 25-30 X 4.5-5.5 μm; basidiosporae suballantoidae ad cylindrico, hyalinae, 6.5-8 X 2-2.5 μm. Holotypus: RLG 16780A (BPI). In calamis mortuo Eugenio jambos.*

**Etymology**: Crowded (referring to basidiocarps).

**Basidiocarps** annual, discoid to shallowly cupulate, crowded on a brownish, tomentose to matted mycelial base, up to 1 mm in diam; outer surface whitish and sugary looking under 30 x lens; margin inrolled on drying and obscuring the hymenial surface; hymenial surface tan to pale brown when dry, rather gummy looking under 30X lens.

**Hyphal system** monomitic; hyphae of basal mycelium thin-walled and hyaline to firm-walled and pale brownish, with occasional clamps, 2.5-5 μm in diam, rarely branched.

**Cystidia** fusoid, thin-walled and hyaline to firm-walled and pale brown, the hyaline ones 27-38 x 4.5-6 μm, with a basal clamp, the brownish ones 27-50 x 4.5-6 μm, with a basal clamp, some with light, amorphous incrustation;

**Basidia** clavate, 2-4 sterigmate, 22-30 x 7-9 μm, apparently with basal clamp but these difficult to discern.

**Basidiospores** ellipsoid, hyaline, smooth, with slightly thickened walls, negative in Melzer's reagent, 7.5-9.5 x 5-6 μm.

RLG 16780A, Hana Highway, Maui, on fallen branch of *Eugenia jambos*, associated with a white rot.

*LENTINUS CRINITUS* (L.: Fr.) Fr. JEA 1494, ravine behind Hemmes residence, Hilo, Hawaii, on dead *Trema orientalis*, associated with a white rot. This specimen agrees well with the description and illustration by Pegler (1983).

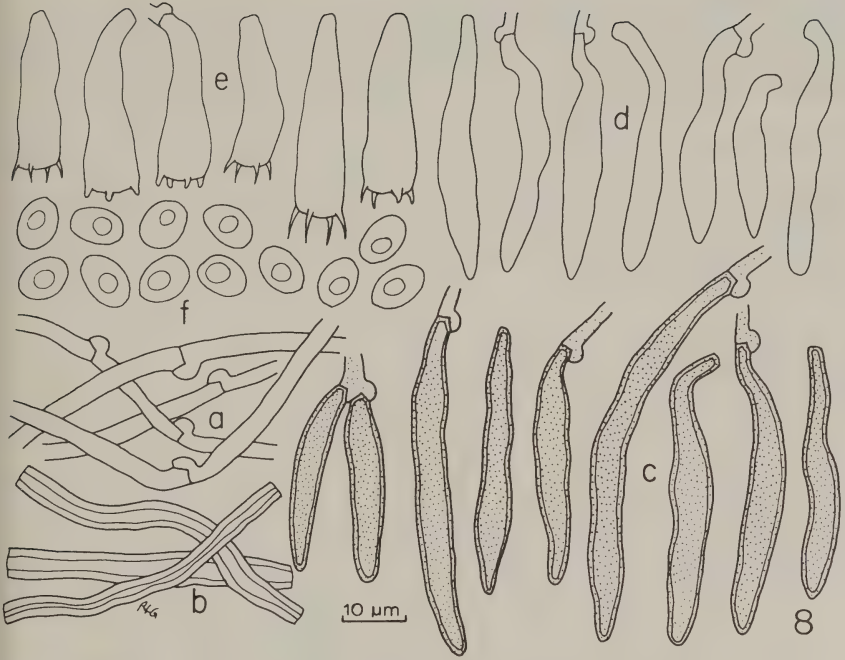

Fig. 8. *Lachnella conferta* (RLG 16780A). a, generative hyphae; b, skeletal hyphae; c, pigmented pilocystidia; d, hyaline pilocystidia; e, basidia; f, basidiospores.

*LENTINUS STRIGOSUS* (Schwein.) Fr. JEA 1463, Hana Highway, on dead, fallen branches of *Eugenia jambos*, associated with a white rot. This collection consists of several small centrally stipitate basidiocarps of a rather uniform brownish color. The dimitic hyphal system, short-cylindric spores, and broad, thick-walled pleurocystidia are typical for *L. strigosus*. This collection would fit into the concept of what has been called *Panus rudis* in past publications in Europe and North America. Pegler (1983) considers *P. rudis* a synonym of *L. strigosus*.

*MEGASPOROPORIA CAVERNULOSA* (Berk.) Ryvarden. RLG 16856, Baptist Church, Hilo, Hawaii, causing a white rot of dead, fallen *Trema orientalis*. This is another taxon with a wide distribution in the American neotropics. It occurs in the Gulf Coast region of the USA.

*PAXILLUS PANUOIDES* Fr. RLG 16815, Bird Park, HVNP, Hawaii, causing brown rot of dead, fallen *Metrosideros polymorpha*.

*PERENNIPORIA TEPHROPORA* (Mont.) Ryvarden. JEA 1491, RLG 16840, MacKenzie State Park, Route 137, Hawaii, on fallen *Casuarina equisetifolia*, causing a white rot. The extensive effused-reflexed basidiocarps with a dark grayish black hymenial surface and tube layers are macroscopically distinct in the field.

*PHANEROCHAETE AUSTRALIS* Jülich Fig. 9

**Basidiocarps** annual, resupinate, effused up to 30 cm, adherent; hymenial surface smooth, Ivory Yellow to Cream Color at first, becoming Deep Olive Buff on older specimens; margin abrupt to thinning out, concolorous; subiculum white, soft and cottony, less than 1 mm thick.

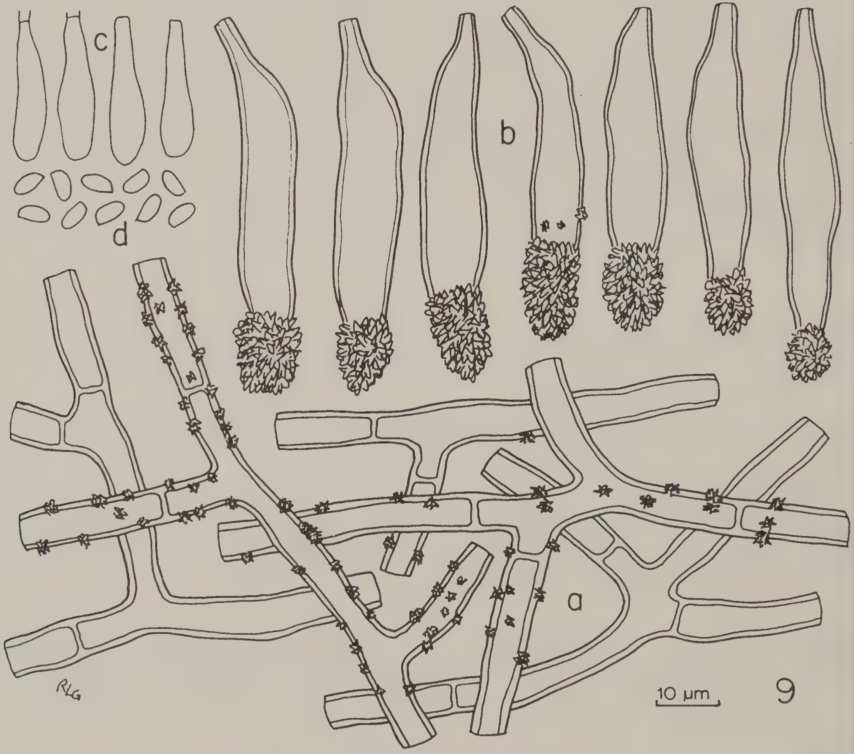

Fig. 9. *Phanerochaete australis* (RLG 16867). a, subicular hyphae; b, cystidia; c, basidia; d, basidiospores.

**Hyphal system** monomitic; subicular hyphae loosely arranged, thick-walled, hyaline, simple-septate, smooth to lightly incrusted, with frequent branching, 5-8 μm in diam; no clamps seen in any of the specimens cited.

**Cystidia** abundant and conspicuous, firm- to thin-walled, apically incrusted with coarse, hyaline crystals, 50-60 x 6-10 μm, simple-septate at the base.

**Basidia** narrowly clavate, 4-sterigmate, 20-24 x 4-5 μm, simple-septate at the base.

**Basidiospores** oblong, hyaline, smooth, thin-walled, negative in Melzer's reagent, 4.5-5 x 2.5-3 μm.

RLG 16847, MacKenzie State Park, Highway 137, Hawaii, on dead, fallen *Casuarina equisetifolia*; 6860, Baptist Church, Hilo, Hawaii, on dead, fallen *Trema orientalis*; RLG 16867, Ravine behind Hemmes residence, Hilo, Hawaii, on fallen branches of *Trema orientalis*; all causing a white rot.

This taxon is in the highly variable *P. sordida* complex and we recognize it mainly on the basis of its short, oblong spores and thin-walled, broad cystidia with only apical incrustation. Clamps apparently do not occur on any hyphae of *P. australis*. It has not been previously reported from the USA.

*PHANEROCHAETE FLAVIDO-ALBA* (Cooke) S. S. Rattan. RLG 16775, near beach, West Maui, Maui, on dead trunk of *Euphorbia* sp.; RLG 16812, Kapuaa Park, Hawaii, on dead branch of living *Prosopis pallida* (kiawe, mesquite), causing a white rot. This is one of only two species found on dead branches of mesquite on the dry west side of the island of Hawaii. It is microscopically distinct because of the large, often ventricose, apically incrusted cystidia.

*PHANEROCHAETE JOSE-FERREIRAE* (D. A. Reid) D. A. Reid. Fig. 10

**Basidiocarps** annual, resupinate, effused up to 6 cm, adherent; hymenial surface smooth, Light Russet-Vinaceous to Vinaceous-Fawn, becoming minutely porose with exposed white subiculum, in older areas becoming darker purplish (Dark Vinaceous-Brown to Dark Vinaceous-Drab); margin thinning out, whitish, arachnoid; subiculum white, less than 100 μm thick.

**Hyphal System** monomitic; subicular hyphae hyaline, thin- to firm-walled, simple-septate with frequent branching, 3.5-5 μm in diam; larger cystidioid hyphae imbedded in hymenium, simple-septate up to 8 μm in diam.

**Cystidia** or other sterile hymenial elements lacking.

**Basidia** clavate, 4-sterigmate, mostly 22-25 x 6-7.5 μm, but some up to 9.5 μm in diam at the apex, simple-septate at the base.

**Basidiospores** allantoid, hyaline, smooth, thin-walled, negative in Melzer's reagent, 7.5-10 x 2.5-3 μm.

JEA 1487, near shore on Highway 137, Hawaii, causing a white rot of dead, fallen *Terminalia catappa* L. (false kamani).

The distinctive characters of this taxon are the relatively large allantoid spores, the lack of cystidia, and the vinaceous color of the hymenial surface. Although this specimen fits *P. jose-ferreirae* better than it does any other described species of *Phanerochaete*, there are some distinctly divergent characters. Reid (1965,1975) and Eriksson et al. (1981) illustrate the basidiospores of *P. jose-ferreirae* as cylindrical and straight.

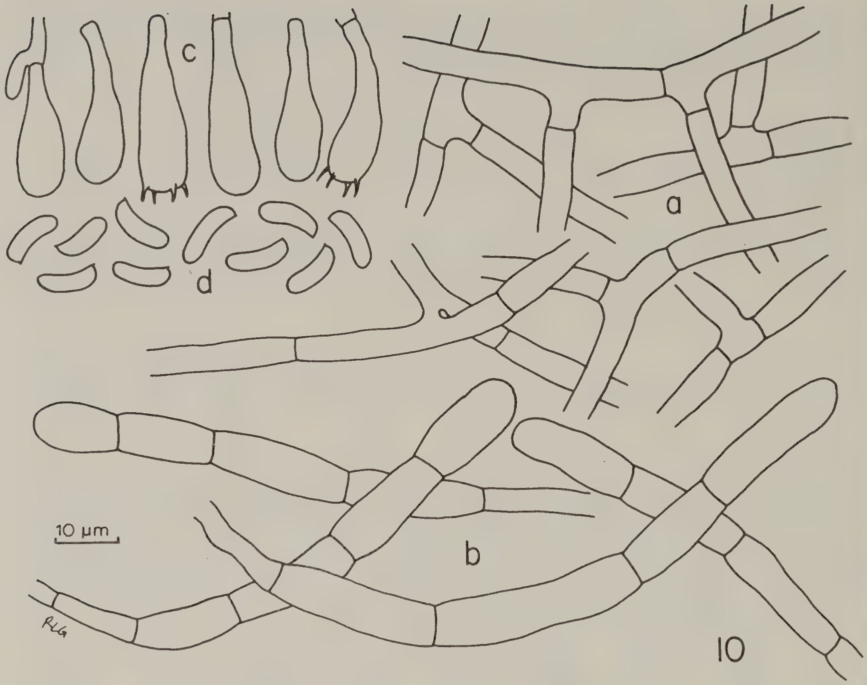

Fig. 10. *Phanerochaete jose-ferreirae* (JEA 1487). a, subicular hyphae; b, cystidioid hyphae; c, basidia, d, basidiospores.

Burdsall (1985) shows them as allantoid to slightly curved as in our specimen cited here. None of the above authors describe the hymenial surface to be colored like that of the Hawaii specimen.

*PHANEROCHAETE MAUIENSIS* Gilb. & Adask., sp. nov. Fig. 11

*Fructificatio annua, resupinata; superficies hymenii cremei ad luteum; systema hypharum monomiticum; hyphae septatae, afibulatae, 2.5-4.5 µm diam; hyphae formitatis candelabris basidia; cystidia conspicua, cylindrica, clavata, vel conica, incrusta, 2-4 µm diam; basidia in candelabris, anguste clavata, 4-sterigmatica, 20-28 X 4.5-6.5 µm; basidiosporae oblongae ad brevi-columnares, 5.5-6 X 2.5-3 µm. Holotypus: JEA 1462 (BPI). In calamis mortuis Eugenio jambos.*
**Etymology**: Of the island of Maui.

**Basidiocarps** annual, resupinate, effused up to 20 cm, adherent, soft and easily flaked off; hymenial surface smooth, Cream Color to Light Buff, when dry with scattered small cracks that expose the underlying white subiculum; margin thinning out, white fimbriate, sterile portion mostly less than 1 mm wide; subiculum white, soft, less than 1 mm thick.

**Hyphal system** monomitic; hyphae simple-septate, hyaline, thin- to firm-walled, narrow and uniform in diam, loosely arranged and readily discernible, with frequent branching, 2.5-4.5 μm in diam; subhymenial hyphae branching repeatedly to give rise to candelabrums of basidia.

**Cystidia** conspicuous, imbedded or projecting, cylindrical to conical or clavate, heavily incrusted with hyaline crystals, hyphal base firm-walled, 2-4 μm in diam, incrusted part up to 70 μm long and 6-15 μm wide.

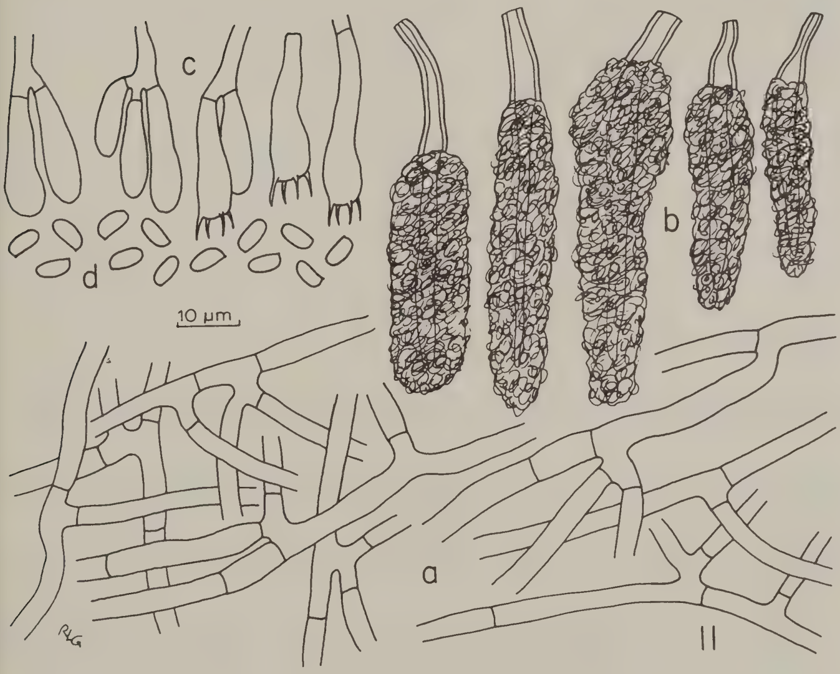

Fig. 11. *Phanerochaete mauiensis* (JEA 1462). a, subicular hyphae; b, cystidia; c, basidia; d, basidiospores.

**Basidia** in complex candelabrums, narrowly clavate, 4-sterigmate, 20-28 x 4.5-6.5 μm, simple-septate at the base.
**Basidiospores** oblong to short-cylindric, hyaline, smooth, negative in Melzer's reagent, 5.5-6 x 2.5-3 μm.
JEA 1462, Mile 6, Hana Highway (No. 360), Maui, on fallen dead branches of *Eugenia jambos;* JEA 1473, Keanae Arboretum, Hana Highway, Maui, on fallen dead branches of *Hibiscus tiliaceus*; RLG 16784, RLG 16787, Hana Highway, Maui, on dead fallen branches of *Eugenia jambos*; RLG 16863, in ravine behind Hemmes residence, Hilo, Hawaii, on dead fallen branches of *Trema orientalis*; causing a white rot.
*P. mauiensis* is most similar to *P. subiculosa*. The latter species differs in having a cordonic margin with yellow to orange cordons. The narrow, uniform subicular hyphae and variable, heavily incrusted cystidia are salient microscopic characters.

*PHELLINUS GILVUS* (Schwein.) Pat. JEA 1480, JEA 1484, Bird Park, HVNP, Hawaii, on *Acacia koa*; RLG 16866, ravine behind Hemmes residence, Hilo, Hawaii; on dead *Trema occidentalis*; RLG 16800, Mile 10, Hana Highway, Maui, on *Eucalyptus* stump, causing a white rot. This common fungus shows the same extreme macroscopic variability of basidiocarps in Hawaii as in the rest of its extensive range.

*PHELLINUS KAWAKAMII* M.J. Larsen, Lombard, & Hodges. JEA 1492, RLG 16850, MacKenzie Park, Highway 137, Hawaii, causing a white pocket rot of roots and butt of living *Casuarina equisetifolia*, typically fruiting at the ground level with basidiocarps covered with fallen needle-like leaves; JEA 1490, Highway 137, Opikihao, Hawaii, on dead *Terminalia catappa*, associated with a white pocket rot with large pockets up to 5 mm wide and 50 mm long, lined with white delignified wood and some yellowish mycelium in later stages. The pockets are separated by thin (.5 mm) partitions of firm, sound, normally colored wood.

*PHELLINUS PUNCTATIFORMIS* (Murr.) Ryvarden. RLG 16862, in ravine behind Hemmes residence, Hilo, Hawaii, on fallen *Trema orientalis*, causing a white rot.

*PHELLINUS RUFITINCTUS* (Cooke) Pat. RLG 16805A, Keanae Arboretum, Hana Highway, Maui, causing a white rot of fallen stems of *Hibiscus tiliaceus*.

*PHLEBIA CHRYSOCREA* (Berk. & M. A. Curtis in Berk.) Burds. Fig. 12

**Basidiocarps** annual, resupinate, effused up to 20 cm or in scattered patches over an extensive area of log surface, adherent; hymenial surface bright yellow when fresh, drying to Light Orange-Yellow to Apricot Yellow, darkening to Antimony Yellow with age, varying from almost smooth to tuberculate or distinctly odontoid with crowded blunt teeth with minutely fimbriate apices; margin abrupt to thinning-out to a whitish, farinaceous film; context pale yellowish, soft, 100-200 μm thick; all tissue instantly turning dark purple with KOH.

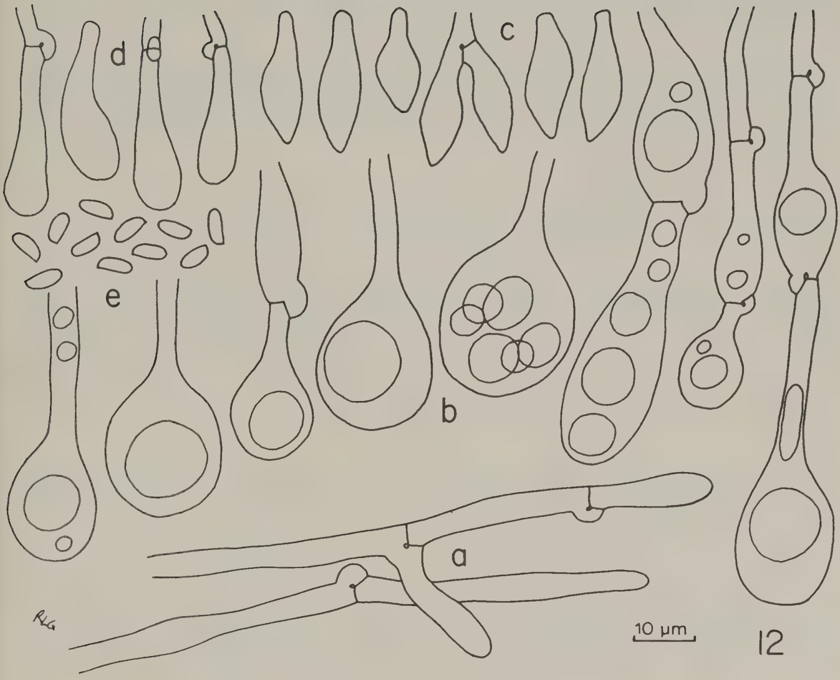

Fig. 12. *Phlebia chrysocrea* (RLG 16820). a, subicular hyphae; b, hyphal elements with vesicular swellings; c, cystidia; d, basidia; e, basidiospores.

**Hyphal system** monomitic; subicular hyphae thin-walled, hyaline, with clamps at all septa, 4-5.5 μm in diam.

**Cystidia** fusiform, abundant, most not projecting past the basidia, thin-walled, 17-22 x 5-7 μm, with a basal clamp; hyphal elements with vesicular swellings also present, the vesicles ellipsoid to subglobose, thin-walled, up to 22 μm in diam, terminal or giving rise to a hyphal extension that produces another vesicle, developing from hyphae with clamp connections, usually containing a single large globule or occasionally more than one.

**Basidia** clavate, 4-sterigmate, 20-28 x 6-7.5 μm, with a basal clamp.

**Basidiospores** cylindric to oblong, hyaline, smooth, thin-walled, negative in Melzer's reagent, 5-6 x 2-2.5 μm.

RLG 16819, 16820, and JEA 1498 Bird Park, HVNP, Hawaii, on fallen *Metrosideros polymorpha* in advanced stages of brown rot.

*PHLEBIA MARTIANA* (Berk. & M. A. Curtis) Parmasto. RLG 16782, Hana Highway, Maui, on dead, fallen branches of *Eugenia jambos*, associated with a white mottled rot. Microscopically, this specimen fits well with *P. martiana*. Macroscopically, it appears to be typical except for the lack of reddish colors. The hymenial surface is distinctly yellowish to yellowish brown. According to descriptions by Burt (1926), Slysh (1960), Eriksson et al. (1981), and Jülich and Stalpers (1980), the color of the hymenial surface is a highly variable character.

*PHLEBIOPSIS PENIOPHOROIDES* Gilb. & Adask., sp. nov. Fig. 13

*Fructificatio annua, resupinata, superficies hymenii grisei ad violaceo-griseo; systema hypharum monomiticum; hyphae septatae, afibulatae, 2-5 diam, agglutinare in subiculo; cystidia abundantia, conica, incrusta, 15-30 X 7-10 μm; basidia anguste clavata, 4-sterigmatica, 15-24 X 3.5-5 μm; basidiosporae oblongae, 4-5 X 2-2.5 μm. Holotypus: JEA 1470 (BPI). In calamis mortuis Spathodeo campanulato.*
**Etymology**: Resembling the genus *Peniophora*.

**Basidiocarps** annual, resupinate, adherent, effused up to 7 cm; hymenial surface smooth, minutely farinose under a 30X lens, Drab Gray to Ecru Drab (pale violaceous gray), margin thinning out, concolorous to whitish; subiculum very thin, pale vinaceous brown.
**Hyphal** system monomitic; hyphae simple-septate, hyaline in KOH, thin-walled, with frequent branching, 2-5 μm in diam, agglutinated in the subiculum and difficult to discern; subhymenial hyphae branching repeatedly to form candelabrums of basidia.
**Cystidia** abundant, imbedded throughout subiculum and also projecting from hymen-

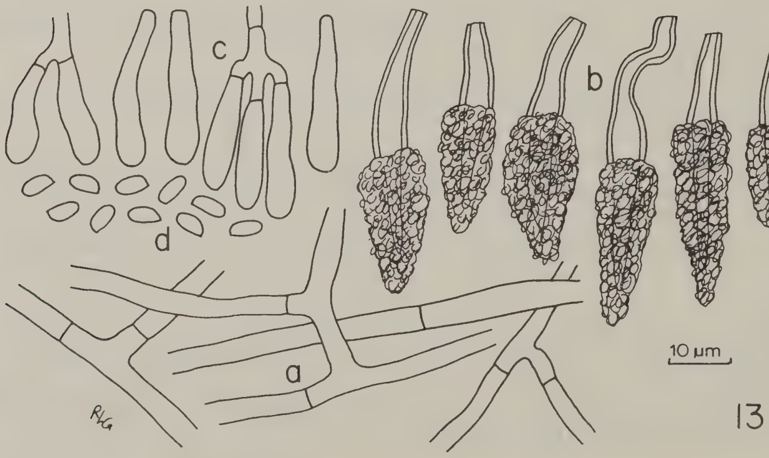

Fig. 13. *Phlebiopsis peniophoroides* (JEA 1470). a, subicular hyphae; b, cystidia; c, basidia; d, basidiospores.

-ium, conical, heavily incrusted with coarse crystals, incrusted portion 15-30 μm long and 7-10 μm in diam, hyphal base firm-walled, up to 5 μm in diam; gloeocystidia absent.

**Basidia** in a dense palisade mixed with cystidia, narrowly clavate, 4-sterigmate, 15-24 x 3.5-5 μm, simple-septate at the base.

**Basidiospores** oblong, hyaline, smooth, thin-walled, negative in Melzer's reagent, 4-5 x 2-2.5 μm.

JEA 1470, Mile 8, Hana Highway, Maui, on fallen branches of *Spathodea campanulata* P. Beauv. (African tulip tree); RLG 16778, RLG 16781, Mile 6, Hana Highway, Maui, on dead, fallen *Eugenia jambos*; associated with a uniform white rot. This taxon has characters like those of *Peniophora crustosa* Cke., as described and illustrated by Cunningham (1963). The absence of clamp connections on hyphae and at the base of basidia, and the small, oblong spores indicate a generic placement other than *Peniophora* sensu stricto. Hjortstam and Ryvarden (1980) indicated that *Phlebiopsis galochroa* (Bres.) Hjortstam & Ryvarden from Brazil has much larger cystidia (50-70 X 7-10 μm) and larger, ellipsoid basidiospores (5-6 X 4 μm).

*PHYSISPORINUS VITREUS* (Pers.: Fr.) P. Karst. RLG 16806A, Keanae Arboretum, Hana Highway, Maui, causing a white rot of fallen branches of *Hibiscus tiliaceus*.

*POLYPORUS ARCULARIUS* Batsch: Fr. JEA 1474, RLG 16804, Keanae Arboretum, Hana Highway, Maui, causing a white rot of fallen branches of *Hibiscus tiliaceus*.

*PYCNOPORUS SANGUINEUS* (L.: Fr.) Murr. RLG 16786, Mile 6, Hana Highway, Maui, causing a white rot of fallen branch of *Eugenia jambos*; RLG 16842, MacKenzie Park, Route 137, Hawaii, on fallen branches of *Casuarina equisetifolia*.

*RESINICIUM BICOLOR* (Fr.) Parmasto. RLG 16855, Baptist church, Hilo, Hawaii, causing a white rot of *Trema orientalis*. The haloed cystidioles in this specimen are unusually large and conspicuous but the other characters fit into the traditional concept of *R. bicolor*.

*RIGIDIPORUS LINEATUS* (Pers.) Ryvarden. RLG 16853, in ravine behind Hemmes residence, Hilo, Hawaii, causing a white rot of fallen *Trema orientalis*.

*RIGIDIPORUS MICROPORUS* (Fr.) Overeem. RLG 16861, in ravine behind Hemmes residence, causing a white rot of fallen *Trema orientalis*.

*RIGIDIPORUS ULMARIUS* (Sowerby: Fr.) Imazeki. RLG 16829, RLG 16830, Bird Park, HVNP, Hawaii, causing a white trunk and butt rot of living *Metrosideros polymorpha*. Basidiocarps were observed on trunks up to 15 feet above ground level.

*RIGIDIPORUS VINCTUS* (Berk.) Ryvarden. RLG 16805, RLG 16808, Keanae Arboretum, Hana Highway, Maui, causing a white rot of dead stems of *Hibiscus tiliaceus* in dense thicket along road bank: RLG 16789, Mile 8, Hana Highway, white rot of dead branches of *Eugenia jambos* L.

*SCOPULOIDES HYDNOIDES* (Cooke & Massee in Cooke) Hjortstam & Ryvarden. JEA 1471, Keanae Arboretum, Hana Highway, Maui, on dead *Hibiscus tiliaceus*; RLG 16799, Mile 8, Hana Highway, on fallen branches of *Spathodea campanulata*; RLG 16835, Bird Park, HVNP, Hawaii, on fallen *Metrosideros polymorpha*; causing a white rot.

*SCHIZOPORA FLAVIPORA* (Cooke) Ryvarden. RLG 16801, Mile 10, Hana Highway, Maui, causing a white rot of dead *Eucalyptus* sp.

*SCYTINOSTROMA GALACTINUM* (Fr.) Donk. RLG 16776, near beach, West Maui, Maui, causing a white rot of fallen *Cocos nucifera* L. (coconut palm); JEA 1460, West Maui, Maui, white rot of *Acacia koa*. Adaskaveg et al. (1990) reported this fungus to be a strong delignifier of wood of datepalm.

*SEBACINA OPALEA* Bourdot & Galzin. RLG 16836, Highway 137, Opihikao, Hawaii, on dead *Terminalia catappa*, associated with a white rot. Basidiospores are broadly ellipsoid, hyaline, smooth, negative in Melzer's reagent, 8-9.5 x 5.5-6 μm.

*SIROBASIDIUM SANDWICENSE* Gilb. & Adask., sp. nov. Fig. 14

*Fructificatio in stromate peritheciali Diatrypellae favaceae, quando recentes albida, opaca, hemisphaerica, circa 1-2 mm lata, firmo-gelatinosa, desicantes in membranam subtilem perlucidulam; systema hypharum monomiticum; hyphae crassitunicatae ad tenuitunicatas, nodoso-septatae, 1.5-3 μm diam; basidia evolventia catenis acropetalis bina ad quaterna; hypobasidia anguste ad late ellipsoidae, pluria didyma cum uno septo obliquo, aliquae tri- aut quadricocca cum duobus vel tribus septis obliquis, 20-30 X 5-6 μm; epibasidia (protosterigmata) gemmantia a cellis hypobasidii, sessilia, decidua, non vi ejecta, late fusiformia, tenuitunicata, 20-30 X 5-6 μm; basidiosporae subglobosae ad globosas, tenuitunicatae, 6-9 μm diam. Holotypus: RLG 16873 (BPI). In stromate peritheciali Diatrypellae favaceae et ramis delapsis Tremae orientalis.*
**Etymology**: Of the Sandwich Islands (old name for Hawaiian Islands).

**Basidiocarps** developing on perithecial stroma of *Diatrypella favacea* (Fr.) Sacc., when fresh conspicuous, whitish, opaque, hemispherical, about 1-2 mm wide, firm-gelatinous, drying to an inconspicuous thin, semitransparent film.
**Hyphal system** monomitic; hyphae distinct, hyaline, slightly thick-walled to thin-walled, with obvious clamps at all septa, occasionally branched, often from clamps, uniformly narrow, 1.5-3 μm in diam.
**Cystidia** or other sterile hymenial elements absent.
**Basidia** developing in acropetal chains of two to four, hypobasidia narrowly to broadly ellipsoid, mostly becoming two-celled with one oblique septum, a few with 3-4 cells with two or three oblique septa, with a basal clamp and all but the terminal one giving rise to an apical hyphal extension that develops into another basidium with a basal clamp, 20-30 x 5-6 μm, epibasidia (protosterigmata) budding off cells of hypobasidium, sessile, deciduous, not forcibly discharged, broadly fusiform, hyaline, thin-walled, negative in Melzer's reagent, with 1 to several oil globules, 20-30 x 5-6 μm.

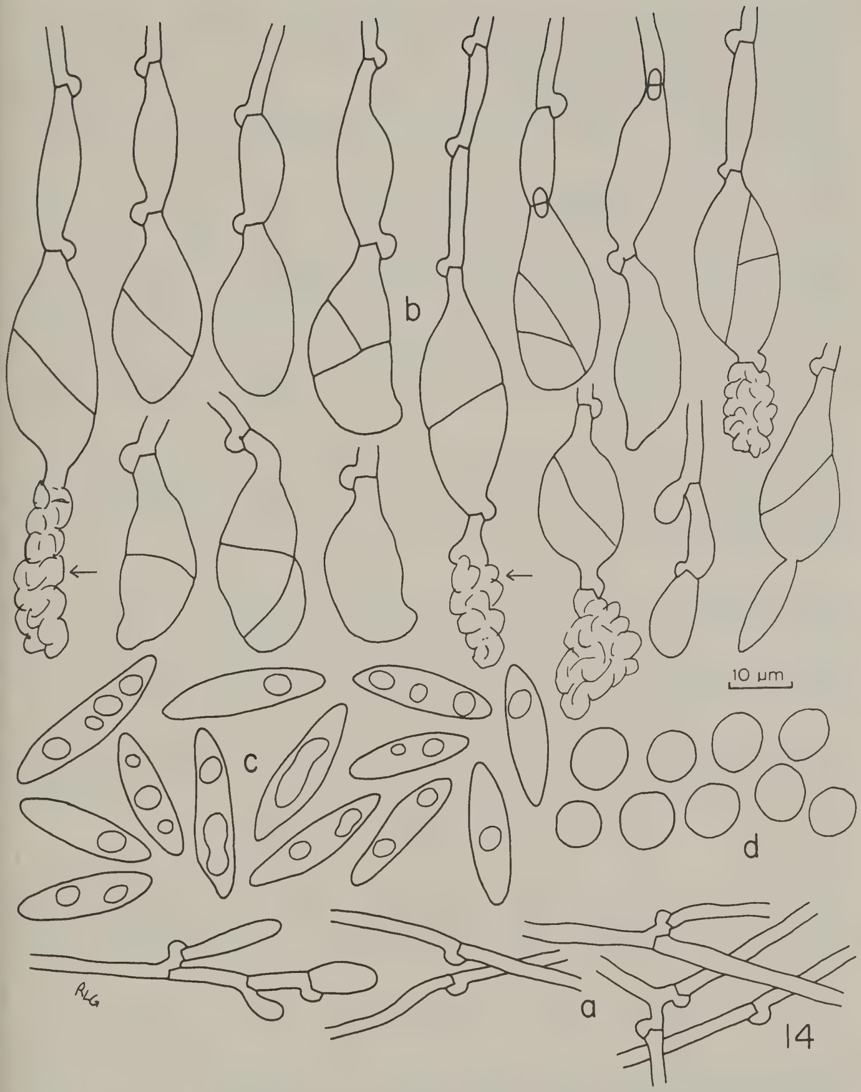

Fig. 14. *Sirobasidium sandwicense* (RLG 16873). a, contextual hyphae; b, hypobasidia (arrows indicate collapsed hypobasidia); c, detached epibasidia; d, basidiospores.

**Basidiospores** presumably developing from deciduous epibasidia, subglobose to globose, thin-walled, hyaline, smooth, negative in Melzer's reagent, 6-9 μm in diam (seen free, not attached to epibasidia).

RLG 16873, ravine behind Hemmes residence, Hilo, Hawaii, on perithecial stroma of *Diatrypella favacea* on fallen branches of *Trema orientalis*, white rot present in underlying wood.

None of the described species of *Sirobasidium* is reported to be associated with fruiting structures of other fungi (Kobayashi, 1962). The most similar ones are *S. albidum* Lagerh. & Pat. and *S. brefeldianum* A. Möller, according to Kobayashi's synopsis and the key of Lowy (1956). Bandoni (1957) explained the mode of development of the basidiospores of *S. sanguineum* Lagerh. & Pat. This pattern of development presumably occurs in *S. sandwicense*, but as yet the germination of deciduous epibasidia and formation of basidiospores has not been observed. The globose spores observed in sections of *S. sandwicense* hymenia are near the size range of basidiospores of *S. sanguineum* (9-11 x 7-9 μm).

*SUBULICYSTIDIUM LONGISPORUM* (Pat.) Parmasto. RLG 16821, Bird Park, HVNP, Hawaii, on fallen *Metrosideros polymorpha*; RLG 16854, RLG 16868 in ravine behind Hemmes residence, Hilo, Hawaii, on fallen branches of *Trema orientalis*; causing a white rot.

*TINCTOPORELLUS EPIMILTINUS* (Berk. & Broome) Ryvarden. JEA 1464, RLG 16788, RLG 16798, Mile 8, Hana Highway, Maui, on dead *Eugenia jambos*; RLG 16798, Baptist Church, Hilo, Hawaii, on dead *Trema orientalis*; JEA 1495, ravine behind Hemmes residence, Hilo, Hawaii, on dead *Trema orientalis*; causing a white rot with red streaks in the decayed wood.

*TRAMETES VERSICOLOR* (L.: Fr.) Pilát. JEA 1482, Bird Park, HVNP, Hawaii, on dead, fallen *Metrosideros polymorpha*; RLG 16772, Hosmer Grove, Haleakala Highway, Maui, on dead, fallen *Eucalyptus globulus*; causing a white rot.

*TRECHISPORA FARINACEA* (Pers.: Fr.) Liberta. RLG 16831, Bird Park, HVNP, causing a white rot of fallen branches of *Metrosideros polymorpha*; RLG 16838, near beach on Route 137, Hawaii, white rot of fallen branch of *Terminalia catappa* L. (false kamani).

*TRECHISPORA LUNATA* (Bourdot & Galzin) Jülich Fig. 15

**Basidiocarps** annual, resupinate, effused up to 10 cm or in small patches, soft, fragile, easily separated; hymenial surface hydnaceous, white to Light Buff or Cream Color, aculei cylindric, single or confluent, crowded, seated on a loosely interwoven, porose subiculum, tapering to a blunt, nonfimbriate apex, up to 0.4 mm long; margin thinning out to a loose, white, arachnoid mycelial film; subiculum white, loosely interwoven, up to 0.5 mm thick.

**Hyphal system** monomitic; subicular hyphae thin-walled, with clamps, occasionally branched, 2-2.5 μm in diam.

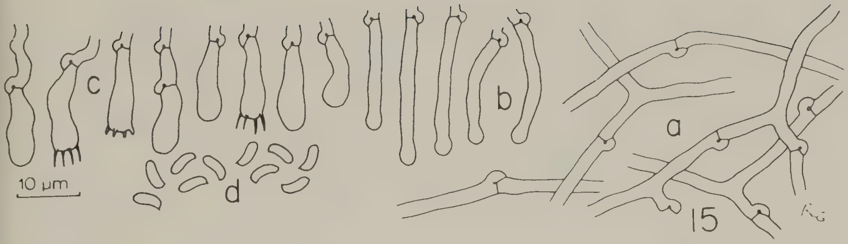

Fig. 15. *Trechispora lunata* (RLG 16814). a, subicular hyphae; b, hyphoid capitate cystidia; c, basidia; d, basidiospores.

**Cystidia** few, hyphoid or slightly capitate, mainly near apices of aculei.
**Basidia** clavate, 4-sterigmate, 8-12 x 3-4.5 $\mu$m, with a basal clamp.
**Basidiospores** cylindric, slightly curved, lunate, hyaline, smooth, thin-walled, negative in Melzer's reagent, 3-3.5 x 1-1.5 $\mu$m.
RLG 16814, Bird Park, HVNP, Hawaii, on dead, fallen *Metrosideros polymorpha*, associated with a white rot.
The distinctive characters of this taxon are the small basidia and lunate basidiospores, hyphoid cystidia, and the loose, cobwebby white subiculum and marginal tissue.

*TUBULICRINIS CHAETOPHORUS* (Höhn.) Donk. RLG 16818, Bird Park, HVNP, Hawaii, causing a white rot of fallen *Metrosideros polymorpha*.

*VARARIA GOMEZII* Boidin & Lanquetin. JEA 1497, ravine behind Hemmes residence, Hilo, Hawaii, causing a white rot of fallen branches of *Trema orientalis*.
This taxon also occurs on juniper branches in the Gulf Coast region (Gilbertson and Blackwell, 1986).

*VESICULOMYCES EPITHELOIDES* Boidin, Lanquetin, & Gilles.
Mycotaxon 16:493. 1983. Fig. 16

**Basidiocarps** annual, resupinate, effused up to 20 cm, adherent but soft and easily scraped from substratum; hymenial surface Cartridge Buff to Warm Buff, smooth; subiculum white, soft and cottony, less than 1 mm thick.
**Hyphal system** monomitic; subicular hyphae thin-walled, hyaline, simple-septate, uniformly narrow, 2-3 $\mu$m in diam.
**Gloeocystidia** abundant, arising deep in the subiculum and extending to the hymenial surface, thin-walled, cylindric with irregular constrictions and swellings, refractive in Melzer's reagent and staining brightly in KOH and phloxine, straight to curved and sinuous, up to 150 $\mu$m long, 5-10 $\mu$m in diam, simple septate at the narrowed base.
**Basidia** narrowly clavate with a swollen base, 4-sterigmate, 25-30 x 5-6 $\mu$m, simple-septate at the base.

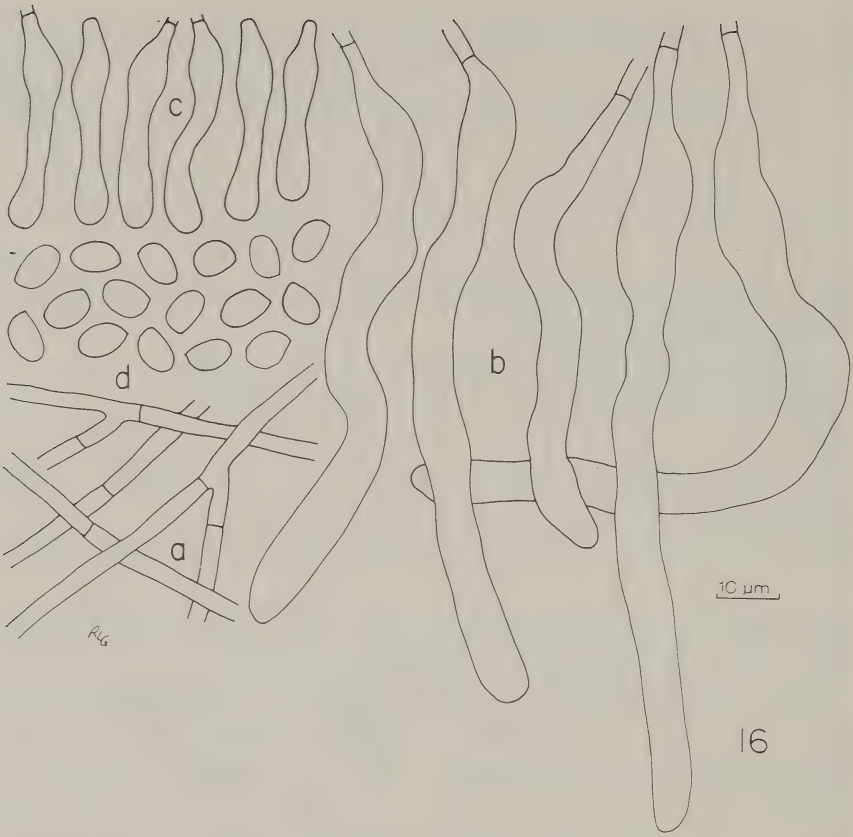

Fig. 16. *Vesiculomyces epitheloides* (RLG 16809). a, subicular hyphae; b, cystidia; c, basidia; d, basidiospores.

**Basidiospores** broadly ellipsoid to subglobose, hyaline, thin-walled, smooth or appearing slightly rough, weakly amyloid in Melzer's reagent and distinctly amyloid in mass, 6-8.5 x 4.5-5.5 $\mu$m.
RLG 16793, Mile 8, Hana Highway, Maui; RLG 16807, RLG 16809, Keanae Arboretum, Hana Highway, Maui, all on dead, fallen branches of *Hibiscus tiliaceus*; causing a white rot.
This taxon differs from the common *V. citrinus* (Pers.) E. Hagstr. in having larger, ellipsoid basidiospores.

*PHLEBIELLA TULASNELLOIDEA* (Höhn. & Litsch.) Oberwinkler. RLG 16794, Mile 6, Hana Highway, Maui, on dead *Hibiscus tiliaceus*, associated with a white rot. Reported from Oahu by Liberta (1962).

## BOTANICAL AND COMMON NAMES OF TREES REPORTED AS SUBSTRATES IN THIS PAPER

(based on Little and Skolmen, 1989).

*Acacia koa* A. Gray; koa
*Aleurites moluccana (L.) Willd.*; kukui or candle nut
*Casuarina equisetifolia* L.; ironwood or beefwood
*Cocos nucifera* L.; coconut palm
*Eucalyptus globulus* Labill.; Tasmanian blue gum
*Eugenia jambos* L.; rose apple or ohia loke
*Hibiscus tiliaceus* L.; hau
*Metrosideros polymorpha* Gaud.; ohia lehua
*Prosopis pallida* (Humb. & Bonpl. ex Willd.) H.B.K.; kiawe or mesquite
*Sapindus saponaria* L.; wingleaf soapberry
*Spathodea campanulata* P. Beauv.; African tulip tree
*Terminalia catappa* L.; false kamani
*Trema orientalis* (L.) Blume; gunpowder tree or charcoal tree

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MYCOTAXON

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# A NEW *CHAETOMIDIUM* FROM OMAN

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## SUMMARY

***Chaetomidium khodense sp. nov.*** on cow dung from the Sultanate of Oman is described and illustrated. The species is characterized by a cephalothecoid peridium, ellipsoidal to broadly fusiform ascospores and irregular disposition of cells in the cellular plates.

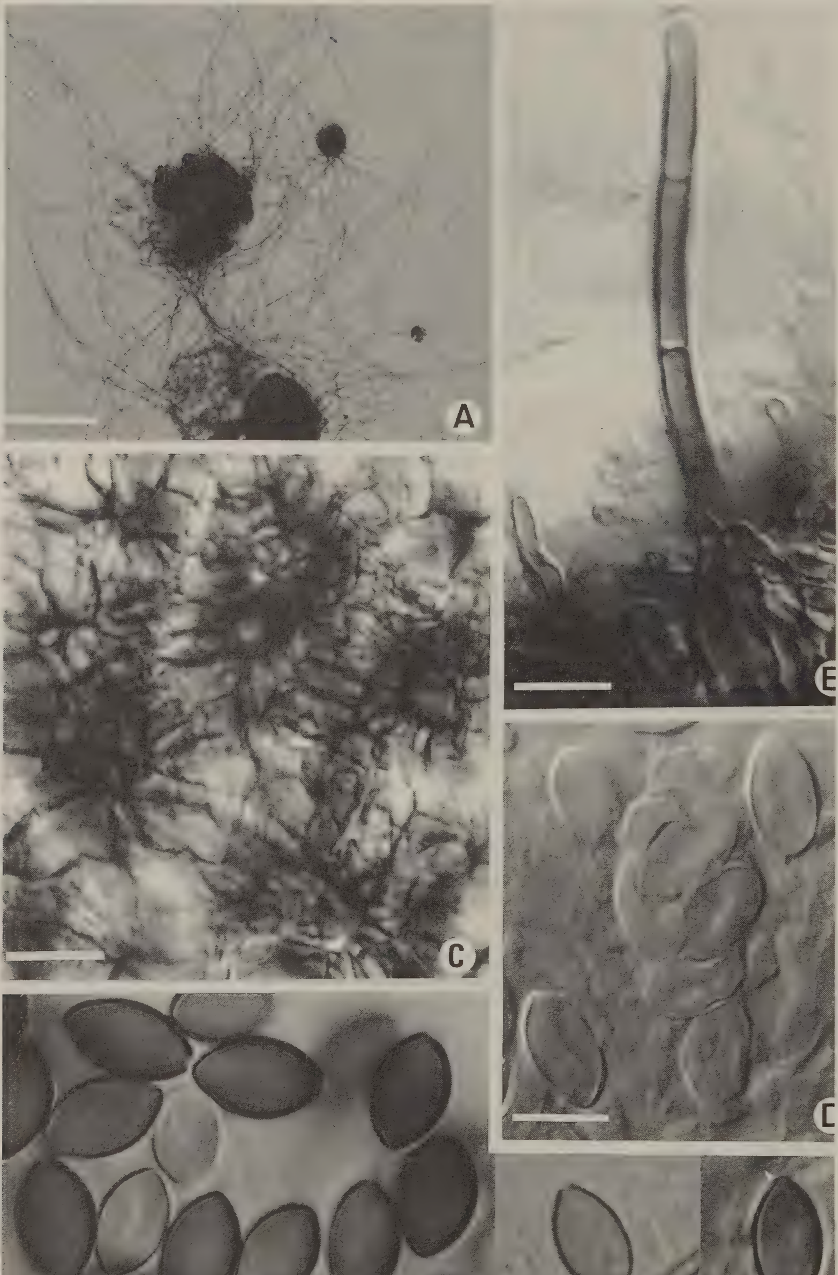
During a survey of coprophilous fungi in the Sultanate of Oman an interesting ascomycete was identified as a species of ***Chaetomidium***. The main characteristics of this fungus do not match those of other species in the genus and it is proposed here as a new species.

***Chaetomidium khodense*** Cano, Guarro et ElShafie ***sp. nov.***

Etym.: after Al-Khod, small town in tha Sultanate of Oman

*Ascocarpa globosa, 250-300 µm crassa, superficialia, nonostiolata, fusco-brunnea vel nigra, pilosa. Pili ascocarpi 500-1000 µm longi, 2.5-3 µm crassi, olivacei brunnei. Peridium ascocarpi cephalothecoideum. Asci clavati, 30-31 x 13-14 µm, octospori, evanescenti. Ascosporae ellipsoideae, 11-13 x 6.5-7 µm, unilateraliter applanatae, ad extremum uniporosae, clarae brunneae ad brunneae, glabrotunicatae. Anamorphosis ignota vel non formata.*

*Holotypus : ex fimo vaccae, in collectione fungorum IMI 356048, Egham, Britannia deposita est. Isotypus* FMR 3688, SOU 14.


A
C
D

***Chaetomidium khodense*** Cano, Guarro & ElShafie ***sp. nov.*** (Fig. 1)

**Ascomata** globose, 250-300 µm diam, dark brown to black, hairy, superficial, nonostiolate; ascomatal hairs 500-1000 µm long, 2.5-3 µm broad in the middle and 5-7 µm broad at the base, straight or flexuous, sometimes slightly coiled at the end, olivaceous brown, septate, wall smooth to finely roughened, thick; **ascomatal peridium** cephalothecoid, consis cellular plates polygonal, 15-20 µm diam, often radiating from the point of origin of a hair, in cross section composed of two distinct layers: an outer layer, corresponding to the cephalothecoid layer, three to four cells (3-4 µm) thick, cells rectangular and dark brown; and an inner wall layer three to four polyhedral cells thick, hyaline to light brown; **asci** clavate, 30-31 x 13-14 µm, evanescent, eight-spored; **ascospores** multiseriate; ellipsoidal or broadly fusiform, slightly flattened on one side with a subapical germ pore (1-1.2 µm diam), initially hyaline to light brown, dark brown at maturity, smooth, 11-13 x 6.5-7 µm. Anamorph not observed.

**Material examined**: ***Chaetomidium khodense:*** FMR 3688, cow dung, Wadi Hina, Dhofar Province, Sultanate of Oman, 20 Oct., 1989, A.E. ElShafie. ***Chaetomidium cephalothecoides:*** strain ex type IMI 180791, on mouse dung, San Bernardino, California, USA, 2 Jan., 1970, G.L. Benny ; FMR 2437, on sheep dung, Carrascoy Hill, Murcia, Spain, 12 March, 1988, M. Valldosera. ***Chaetomidium arxii***: strain ex type, ATCC 38819, on kangaroo-rat dung, San Bernardino, California, USA, 29 July, 1974, G.L. Benny.

We were unable to obtain fertile cultures of this fungus on any of media tried. Only on oat meal agar did we detect sterile ascomata.

At the present, the genus ***Chaetomidium*** comprises seven species (v. Arx *et al.*, 1988), two of which ***C. arxii*** Benny (Benny, 1980) and ***C. cephalothecoides*** (Malloch et Benny) v. Arx (Malloch and Benny, 1973),

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Fig. 1. ***Chaetomidium khodense*** (FMR 3688). **A,** Ascomata (bar= 300 µm). **B,** young ascomatal hair (bar= 10 µm). **C,** polygonal cellular plates (bar= 10 µm). **D,** asci (bar= 10 µm). **E,** ascospores (bar= 10 µm).

in common with *C.* ***khodense***, have cephalothecoid peridia. They differ in the following characteristics; firstly, *C. arxii* has straight hairs and obovate and bigger ascospores (13.9 - 15.2 x 10.7 - 11.4 µm) than *C.* ***khodense***. *C.* ***cephalothecoides*** (Fig. 2), a very close species, whose two known isolates were also found in dung; mouse dung in one case (Malloch and Benny, 1973) and sheep dung in the other (Valldosera and Guarro, 1992), has thicker circinate hairs (4.5 - 8 µm diam), broader ascospores (8.0 - 10.5 µm) and larger peridium cellular plates (16 - 50 µm diam), than *C.* ***khodense***. The disposition of the cells in the cellular plates is also different; in *C.* ***cephalothecoides*** the thick-walled (1-1.5 µm) cells are disposed more or less regularly in a petaloid pattern and they are clearly rectangular; in *C.* ***khodense***, the cells are more irregularly disposed and with sinuose and thinner walls (less than 0.5 µm).

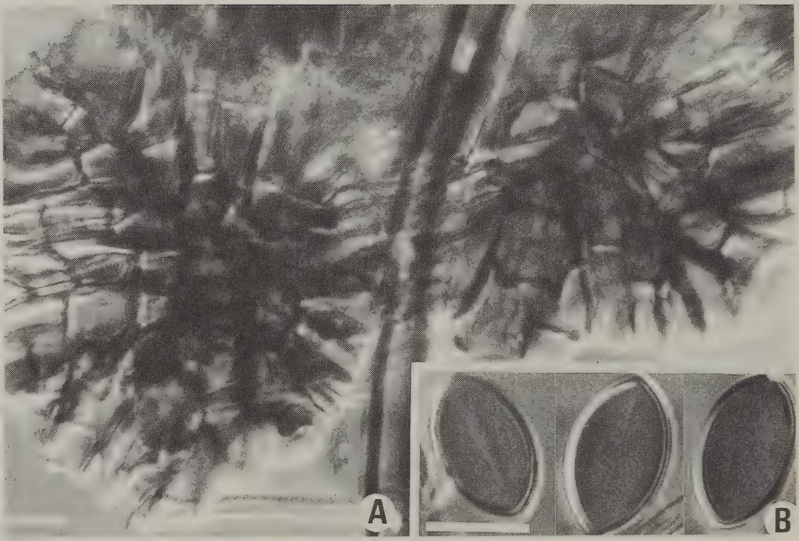

Fig. 2. ***Chaetomidium cephalothecoides*** (IMI 180791). **A,** polygonal cellular plates (bar= 10 µm). **B,** ascospores (bar= 10 µm).

## ACKNOWLEDGEMENTS

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# TWO NEW SPECIES OF PARMELIACEAE (LICHENIZED ASCOMYCOTINA) FROM SOUTH AMERICA

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ABSTRACT : The species *Parmotrema wrightii* Ferraro & Elix and *Rimeliella cristobalii* Ferraro & Elix are described as new. *Parmotrema wrightii* is known only from Mato Grosso do Sul State, Brazil, while *R. cristobalii* is quite widely distributed in northern Argentina and Bolivia.

South America appears to be a major centre of speciation of a number of parmelioid genera, in particular *Hypotrachyna, Parmotrema* and *Rimeliella*. As a result of further studies of the regional species of Parmeliaceae (Ferraro 1979), we are describing two new species in the latter two genera. Chemical constituents were identified by thin layer chromatography (Culberson 1972; Culberson & Amman, 1979; Culberson, Culberson & Johnson 1981; Culberson & Johnson 1982; Elix, Johnston & Parker 1989; Elix & Ernst-Russell 1993) and high performance liquid chromatography (Elix & Venables 1993) and by comparison with authentic samples.

**Parmotrema wrightii** Ferraro & Elix sp. nov. Figure 1

Thallus laxe adnatus, coriaceus, corticola, cinereo-glaucescens. Lobi 4-6 mm lati, ad apices rotundatos, margines eciliati; superne emaculati, isidiis sorediisque destitutis; medulla alba; subtus nigri. Apothecia

subpedicellata, 2-5 mm diametro, eperforata; sporae 20-22 x 12-14 µm. Pycnidia laminalia, conidiis sublageniformibus, 6-7 x 1 µm. Thallus atranorinum, chloroatranorinum, acidum norsticticum, acidum echinocarpicum et acidum connorsticticum (minimo) continens.
*Type*. Brazil. Mato Grosso do Sul State. On rocks, 7 km west of Ribas do Rio Pardo, *A. Krapovickas & C. L. Cristóbal 34389*; CTES-holotype.

*Thallus* corticolous, adnate, grey but becoming brown in the herbarium, coriaceous, forming rosettes 7-15 cm in diam. *Lobes* irregular, 4-6 mm wide, laciniae and cilia lacking. *Upper surface* continuous, shiny, lacking soredia and isidia. *Lower surface* black, sparsely rhizinate, rhizines robust, concolorous with the lower surface, mainly simple, with a broad, brown, bare marginal zone. *Apothecia* common, substipitate, disc dark brown, imperforate, 2-5 mm diam., spores (8), hyaline, ellipsoid, 20-22 x 12-14 µm. *Pycnidia* frequent, laminal; conidia sublageniform, 6-7 x 1 µm.
*Chemistry*. Cortex K+ yellow, medulla K+ yellow turning dark red, P+ orange; containing atranorin, chloroatranorin, norstictic acid (major), echinocarpic acid (major) and connorstictic acid (minor).

The thallus of *Parmotrema wrightii* closely resembles that of the Australian species *P. queenslandense* Elix, but the thallus of the former is even thicker and more coriaceous. These species also exhibit different substrate preferences (*P. queenslandense* is primarily saxicolous) and chemistry (*P. queenslandense* contains medullary fumarprotocetraric acid and succinprotocetraric acid).

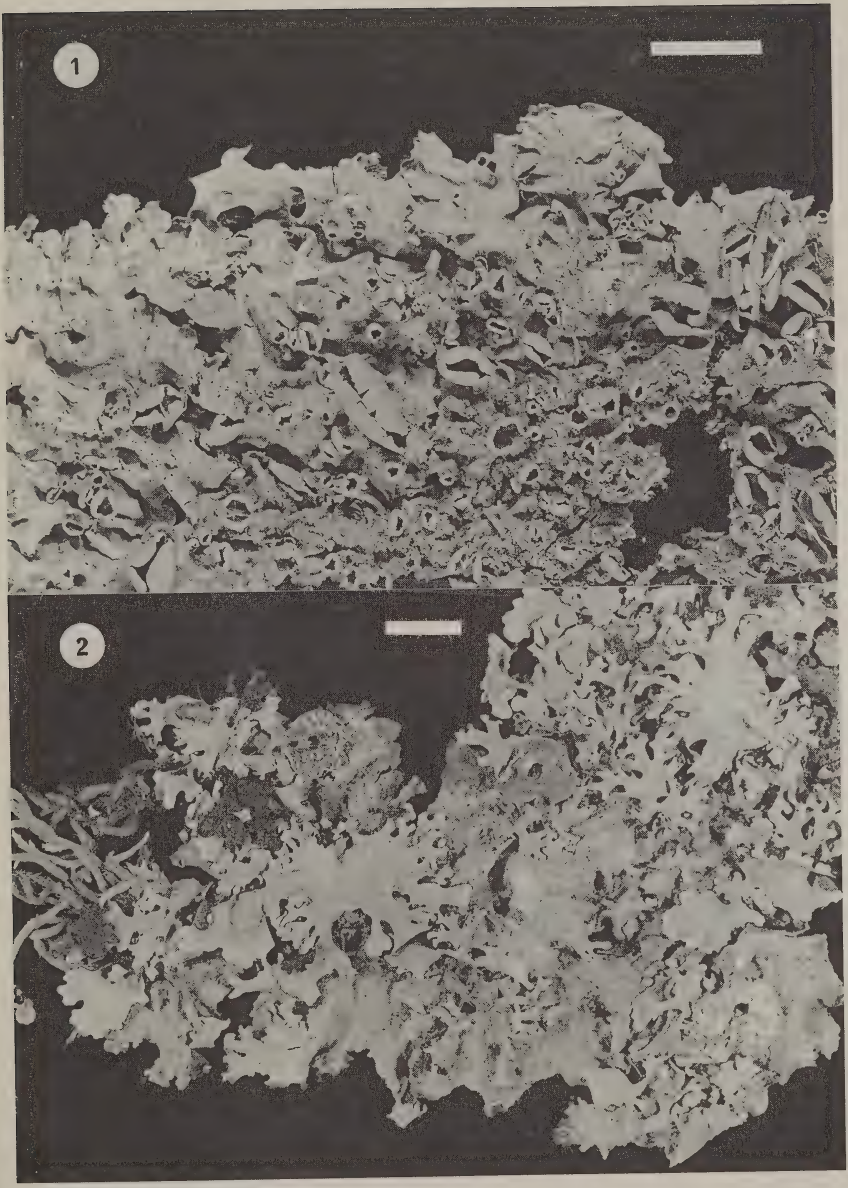
At present this new species is known only from the type collection. This species is named in honour of Dr. Jorge Wright, professor of mycology at the Universidad de Buenos Aires.

**Rimeliella cristobalii** Ferraro & Elix sp. nov. Figure 2

Species cum thallo ut in *Rimeliella subcaperata* sed ab hac specie lobi laciniatibus et norlobaridonum et loxodinum continente differt.

*Type*. Argentina. Corrientes Province. Depto. Ituzaingó, Rincón Ombú Chico, *L. I. Ferraro, S. Tressens, A. Schinini & M. Gonzales 687*; 25.iv.1975; CTES-holotype.

*Thallus* corticolous, loosely adnate, coriaceous, mineral grey, 4-20 cm diam. *Lobes* rotund, 3-10 (-20) mm wide, margins broadly crenate, ciliate, cilia abundant, 0.5-2.5 mm long, rarely sparsely branched, lobes often becoming laciniate dissected, laciniae 1.0-2.0 mm wide, 0.5-8.0 mm long, ± radiating. *Upper surface* plane, shiny, strongly effigurate white-maculate, becoming cracked with age, lacking soredia and isidia. *Lower surface* brown at the margins, black or brown-black at the centre; rhizines dimorphous, short rhizinate or papillate to the margins, short rhizines



Figures. New species of Parmeliaceae. 1 *Parmotrema wrightii* (holotype in CTES); 2 *Rimeliella cristobalii* (holotype in CTES). Scale = 10 mm.

simple, dense, to 0.3 mm long, long rhizines coarse, sparse, formed in groups, more than 1.0-2.0 mm long. *Apothecia* common, stipitate, 4-10 mm diam., disc perforate, thalline exciple rugose, strongly white-maculate; spores 13-16 x 7-10 µm. *Pycnidia* common, conidia filiform, 10-14 x 1 µm.

*Chemistry*. Cortex K+ yellow; medulla K+ yellow turning red, C-, P+ orange; containing atranorin, chloroatranorin, salazinic acid (major), norlobaridone (major), consalazinic acid (minor/trace), loxodin (minor/trace).

The following characters, present in this species, are characteristic of the genus *Rimeliella* Kurokawa: broad lobes with rotund apices, effigurate-maculate upper surface, dimorphous rhizines, sparsely branched cilia and filiform conidia (Kurokawa 1991). Morphologically this species resembles *Rimeliella subcaperata* (Krempelh.) Kurok. and *Rimeliella recipienda* (Nyl.) Kurok. but is clearly distinguished from those species by the laciniate margins of the lobes. These three species also differ chemically as *R. subcaperata* contains medullary salazinic acid, *R. recipienda* loxodin and norlobaridone, while *R. cristobalii* contains significant quantities of both salazinic acid and norlobaridone. This new species is named in honour of Dr. Carmen Lelia Cristóbal of the Instituto de Botánica del Nordeste, Corrientes.

*Specimens Examined*
ARGENTINA. Corrientes Province. Depto. Saladas, in woodland edging the road, route 12, 33.5 km S of the turn-off to Empedrado, *L. Ferraro 2862*, 27.xii.1983 (CTES). Depto. San Cosme, on *Prosopsis* sp. in forest, Paso de La Patria, old road to Paso de La Patria, *L. Ferraro 1232*, 12.iii.1978 (CTES, US). Chaco Province. Depto. Gral. San Martín, on bark of *Schinopsis balansae* in a deforested area near the UNITAN tannery, Pampa del Indio, *Barreto*, ix.1991 (CTES). Depto. Primero de Mayo, Colonia Benitez, INTA Reserve, *L. Ferraro et al. 1796*, 16.v.1979 (BG, CTES); on wooden veranda of bridge, road to Colonia Benitez, Río Tragadero, *L. Ferraro et al. 1810*, 16.v.1979 (CTES).
BOLIVIA. Depto. Tarija, Gran Chaco, Villa Montes, *A. Krapovickas et al. 33913*, 2.iv.1977 (CTES, US).

## ACKNOWLEDGEMENTS

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# NOTE ON HOLOTYPE OF PSEUDOCERCOSPORA SIEBERIANA SP. NOV. FROM INDIA

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While describing *Pseudocercospora sieberiana* Raghu Ram and Mallaiah sp.nov. from India, (Mycotaxon 45: 405-408), the host *Cassia occidentalis* L. (IMI 344152) was specified to serve as the holotype. The citation of *Cassia auriculata* L. (IMI 344153) also as the holotype was by oversight. The latter is hence to be treated merely as a paratype and the lastword in 19th line on page 406 should be read as 'paratypus'.

Thanks are due to Prof. D. L. Hawksworth, of International Mycological Institute, England, drawing our attention to the need for publishing the correction.

## REFERENCE

RAGHU RAM,M and MALLAIAH, K.V. (1992) *Pseudocercospora sieberiana* sp. nov. from India. *Mycotaxon* 45: 405-408.

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# REEXAMINATION OF *PLUTEUS* TYPE SPECIMENS: TYPES HOUSED AT THE NEW YORK BOTANICAL GARDEN

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ABSTRACT— Anatomical features of thirty-nine types of *Pluteus*, housed at the New York Botanical Garden (NY), were reexamined. Two belong to section *Pluteus*, 21 to section *Hispidoderma*, and 15 to section *Celluloderma*. Critical comparisons were made with previous studies, and, where noted, significant differences or additional features or both are reported. Illustrations, heretofore unavailable, are provided for all types. The physical condition of each type is also noted.

KEY WORDS: Agaricales, *Celluloderma*, *Hispidoderma*, NY, Pluteaceae, *Pluteus*, reexamination, type.

## INTRODUCTION

The genus *Pluteus* Fr. (Pluteaceae, Agaricales) is characterized by the following features: stipe central; lamellae free, white when young, salmon-pink when mature; annulus and volva absent; context of the pileus most frequently white, consisting of fleshy, inamyloid tissue. Basidia usually 4-sterigmate, clavate. Basidiospores pinkish brown in mass (Singer 1986), walls cyanophilic (Stuntz 1977), smooth, inamyloid, hyaline in KOH, germ pore absent, usually lacking suprahilar depression or applanation, hilar appendix conspicuous or inconspicuous. Hymenophoral trama inverse in mature basidioma, hyphae inamyloid, with or without clamp connections, trama homeomerous. Pileipellis a palisadoderm of sphaeropedunculate cells or a trichoderm of filamentous hyphae with allantoid or cylindric-fusoid end cells.

The genus is divided into three sections as follows:

Pileipellis a palisadoderm of sphaeropedunculate cells... Section *Celluloderma* Fayod
Pileipellis a trichoderm of filamentous hyphae with
  allantoid or cylindric-fusoid end cells
    Pleurocystidia metuloid ................................ Section *Pluteus* Fr.
    Pleurocystidia thin-walled, sometimes collapsing... Section *Hispidoderma* Fayod

Fungal type studies are important in establishing species concepts and relationships, determining synonymy, and aiding in the development of a world-wide system of taxonomy for fleshy fungi (Ammirati and Ovrebo, 1979; Mueller, 1992). Since type specimens of agarics are destructible and irreplaceable, all who study them have an obligation to publish results of their studies, not just their conclusions (Smith and Stuntz, 1958). Even though Singer (1956), Smith and Stuntz (1958), and Homola (1972) published studies of American types of *Pluteus*, some of our observations on the type specimens differed from theirs or we observed certain anatomical characters not included in their analyses. Further, no illustrations accompanied Smith and Stuntz's (1958) publication on *Pluteus* types, and Singer (1956) illustrated only some features of selected species. Therefore, variations from previous reports and new data we observed are presented herein along with a set of illustrations of important anatomical characters of all 39 types.

## MATERIALS AND METHODS

Special care was taken during this study because of the possibility of accidentally getting type specimens mixed while studying them (Singer, 1956; Smith and Stuntz, 1958). One type was studied at a time, and it was carefully replaced in its box before the next box was opened.

Standard techniques were used for the analysis of micro-morphological (anatomical) characters (Largent *et al.*, 1977; Singer, 1986). Examinations were made using an Olympus BH2 bright-field microscope. Illustrations of characters were made by hand and with the aid of a drawing tube. All observations were made on material mounted in 3% KOH, and, unless otherwise noted, all structures described below were hyaline in KOH. Although Smith and Stuntz (1958) reported a pale lilac color of the basidiospores when mounted in KOH under oil immersion (1000x), we found this to be an artifact due to light refraction. The following definitions are employed here to describe pleurocystidia. "Cervinus-type" refers to pleurocystidia with apical ornamentations while "magnus-type" indicates pleurocystidia without apical ornamentations (modified after Singer, 1956).

In our study, we had the advantage of the observations by Singer (1956), Smith and Stuntz (1958), and Homola (1972) for comparative purposes. We agree with them that the structure of pileipellis elements, thickness of pleurocystidial walls, structure of cheilocystidia, presence or absence of clamp connections, and basidiospore size are taxonomically important. In addition, we determined that there are other taxonomically useful character sets that have not been well documented or deemed important by others. These included fragility of basidiospores, basidiospore dimorphism and cystidial mucilage. They are noted below where appropriate.

An objective comparison to evaluate the taxonomic proximity of a few anatomically similar species has been difficult due to the non-comprehensiveness of morphological data on them.

Because Smith and Stuntz's (1958) publication contains detailed information on morphology and particularly anatomy of many *Pluteus* types, we present complete anatomical data (see *Data)* only on those species that were not included in their work. For other species, only the variations or additional characters or both we observed are noted (see *Additional data)*; for full descriptions, including repetitive details also noted by other workers, consult Banerjee (1992). Morphological data for the types are available in the original descriptions and, for many, in Smith and Stuntz (1958).

The physical condition of each type specimen was estimated subjectively. Satisfactory condition indicates a specimen that can be handled properly without risk of destroying it and the presence of at least one entire, contaminant-free, well-dried basidioma.

Herbarium acronyms are taken from Holmgren et al. (1990).

## DESCRIPTIONS AND OBSERVATIONS

***Pluteus admirabilis*** (Peck) Peck, Ann. Rep. New York St. Mus. 38: 137. 1885. **Fig. 1.**

≡ *Agaricus admirabilis* Peck, Ann. Rep. New York St. Mus. 24: 64. 1872.

*DATA:* Basidiospores 6-7 x 4.8-6 µm; ovate-subglobose with a conspicuous hilar appendix; smooth; wall slightly thickened. Basidia 20-25 x 7-8.2 µm; 4-sterigmate. Pleurocystidia infrequent; 45-65 x 12-17.8 µm; fusoid-ventricose with an acute to sometime obtuse apex; smooth; thin-walled; hyaline. Cheilocystidia infrequent; 30-42 x 10-21.8 µm; clavate to broadly fusoid-ventricose; smooth; thin-walled; hyaline. Pileipellis a palisade of clavate to pyriform vesiculose-pedicellate cells; (11-)20-23(-28) µm in diameter; thin-walled, hyaline to yellowish within. Clamp connections absent.

*TYPE*: Solitary to gregarious on deciduous logs. Greig, Lewis Co., New York. *Peck, s.n.* Holotype, NYS!, isotype, NY!. Satisfactory.

*DISCUSSION:* Smith and Stuntz (1958) did not describe the type. The orange-yellow pileus and yellow stipe are the most distinctive characters. Homola (1972), whose data apparently include information from other collections as well as the type, reported abundant pleurocystidia, but we found them to be infrequent. Murrill (1917) and Singer (1956) considered this species synonymous with *P. chrysophlebius* (Berk. et Rav.) Sacc. Peck (1885) distinguished it from *P. chrysophlebius* by its umbonate, hygrophanous pileus and yellow stipe and lamellae. Additional similar-looking species include *P. aurantiacus* Murr., *P. melleus* Murr., and *P. rugosidiscus* Murr. (See observations on these types for additional information). *Pluteus admirabilis* belongs to section *Celluloderma.*

***Pluteus alachuanus*** Murr., Proc. Florida Acad. Sci. 7: 118. 1944 (1945). **Fig. 2.**

*DATA:* Basidiospores 5.8-7 x 4.6-5.8 µm; broadly ellipsoid to subglobose; smooth, with a conspicuous hilar appendix. Basidia 18-24 x 6-9.2 µm; 4-sterigmate; sterigmata incurved, 2.4-3.4 µm long. Pleurocystidia infrequent; 34-48.2 x 18.2-20.8 µm; broadly fusoid with an obtuse apex, smooth, thin-walled, hyaline. Cheilocystidia more infrequent than pleurocystidia; 30-48(-57.6) x 18-20.6 µm; shape similar to pleurocystidia, some clavate; smooth, thin-walled, hyaline. Pileipellis a palisadoderm of vesiculose cells, 20-48.2 µm in diameter, filled with brown-fuscous content. Clamp connections not seen on pileipellis hyphae.

*TYPE:* Gregarious on a rotten sweet-gum log in a low hammock at Magnesia Springs, Florida. February 11, 1939. *Murrill F 18713*. Holotype, FLAS!, isotype, NY!. In satisfactory condition.

*DISCUSSION:* Smith and Stuntz (1958) did not describe the type. The spherical, vesiculose elements with brown-fuscous content in the pileipellis are distinctive. Murrill (1944) described globose basidiospores 5 µm diameter, but we did not find them. According to Singer (1956), this species is synonymous with *P. jamaicensis* Murr. But, based on the comparison of anatomical characters of these two species (see notes on *P. jamaicensis* below), we believe they are distinct. *P. alachuanus* belongs to section *Celluloderma.*

***Pluteus atriavellaneus*** Murr., N. Amer. Fl. 10: 131. 1917. **Fig. 3.**

*TYPE: Murrill 673*. Holotype, NY!. Very little of the type remains in satisfactory condition.

*DISCUSSION:* With some uncertainty, Singer (1956) considered *P. compressipes* Murr. to be a synonym of *P. atriavellaneus.* Like Smith and Stuntz (1958), we found some clamp connections and thin-walled and often collapsing spores in *P. compressipes* (see *P. compressipes* below). Therefore, the absence of both clamp connections and thin-walled collapsing spores in *P. atriavellaneus* support the maintenance of these two species as separate entities. *P. atriavellaneus* belongs to section *Hispidoderma.*

***Pluteus aurantiacus*** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 4.**

*ADDITIONAL DATA:* Basidiospores 6.2-7.6 x 4.6-5.6 µm, some adhering to the apical mucilage cap of some pleurocystidia.

*TYPE: F. S. Earle 1664*. Holotype, NY!. Very little of the type remains in satisfactory condition.

*DISCUSSION:* Singer (1956) considered this species to be synonymous with *P. aurantiorugosus* (Trog) Sacc. which he concluded was an earlier name for *P. coccineus* (Mass.) Lange and *P. caloceps* Atk. This may or may not be true because even though the basidiospores of *Pluteus aurantiacus* and *P. coccineus* are similar in size and their stipe is yellow and glabrous (Smith and Stuntz, 1958), the fresh pileus of *P. aurantiacus* is deep orange-yellow (Murrill,1917) while *P. aurantiorugosus* has a distinctive red to orange-

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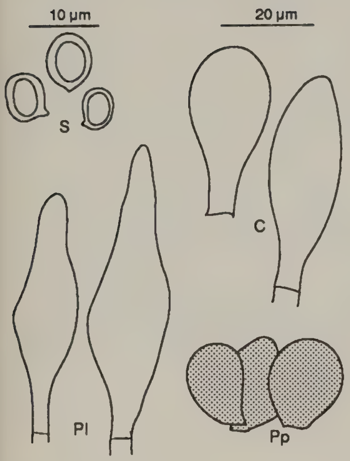
Figs. 1-6. Anatomical characters of *Pluteus* types. 1. *Pluteus admirabilis*. 2. *P. alachuanus*. 3. *P. atriavellaneous*. 4. *P. aurantiacus*. 5. *P. avellaneus*. 6. *P. californicus*. (C = Cheilocystidia; Pl = Pleurocystidia; Pp = Elements of the pileipellis; S = Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures).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C
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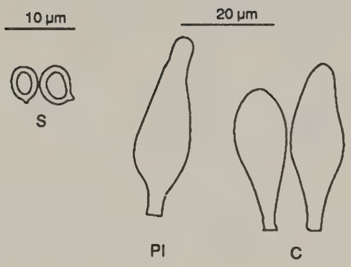
①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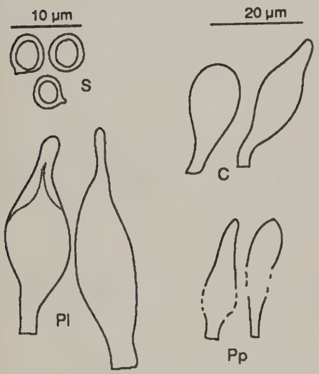
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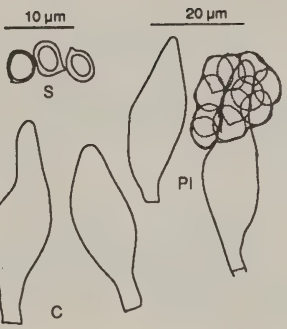
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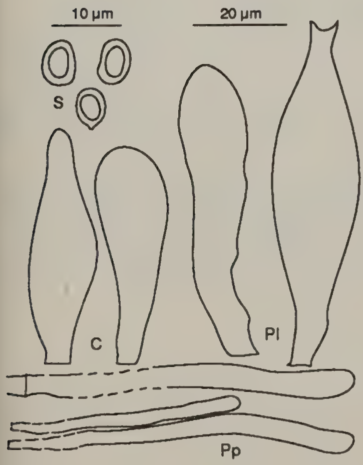
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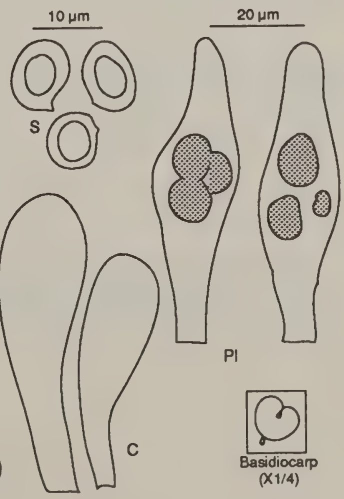
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C
Basidiocarp
(X1/4)

⑥

vermillion pileus when young and cottony mycelium at the stipe base (Homola, 1972). Hence, the difference is there but it may not be significant. *Pluteus aurantiacus* belongs to section *Celluloderma.*

***Pluteus avellaneus*** Murr., N. Amer. Fl. 10: 133. 1917. **Fig. 5.**

*TYPE: W. A. and E. L. Murrill 91.* Holotype, NY!. Little remains in unsatisfactory condition.

*DISCUSSION:* Singer (1956) reported numerous clamp connections and somewhat larger basidiospores. The type is apparently a mixture of two species, as two kinds of pilei—one purple-brown (a fragment), the other grayish brown (most likely this type), were in the same box. We saw neither the ventricose pileipellis elements nor the third form of pleurocystidia reported by Smith and Stuntz (1958). Singer (1956) did not mention any pileipellis elements in his type description. He considers this species synonymous with *P. umbrinidiscus* Murr. (see observations on *P. umbrinidiscus* below). *Pluteus avellaneus* belongs to section *Hispidoderma* .

***Pluteus californicus*** McClatchie, Proc. So. Calif. Acad. Sci. 1: 384. 1897. **Fig. 6.**

*TYPE: McClatchie, s. n.* Holotype, NY!. Satisfactory.

*DISCUSSION:* The greenish gray pileus is a distinctive character of this taxon. Although there are some similarities between *P. californicus* and *P. rugosidiscus* in the color and rugose nature of the pileus, they differ in the frequency and shape of the pleurocystidia (Homola, 1972). This species belongs to section *Celluloderma.*

***Pluteus campanulatus*** Murr., N. Amer. Fl. 10: 131. 1917. **Fig. 7.**

*ADDITIONAL DATA:* Pleurocystidia very infrequent; 45-61 x 13-16 µm; fusoid, thin-walled, readily collapsing; hyaline. Cheilocystidia 35-39 x 11-14 µm; fusoid, thin-walled, readily collapsing; hyaline. Pedicellate-vesiculose to elliptic elements of the pileipellis 28-42 x 45-57 µm.

*TYPE: Underwood and F. S. Earle 655.* Holotype, NY!. The hymenium of the type is almost completely destroyed by insect larvae. Very little of the specimen remains in unsatisfactory condition.

*DISCUSSION:* The basidiomata have the stature of *P. admirabilis.* Because of the condition of the type, Singer (1956) cited this taxon as *incertae sedis. P. campanulatus* belongs to section *Celluloderma.*

***Pluteus compressipes*** Murr., N. Amer. Fl. 10: 137. 1917. **Fig. 8.**

*TYPE: W. A. and E. L. Murrill 118.* Holotype, NY!. The type is not well-preserved as the pileus is contaminated. Very little of the specimen remains. Unsatisfactory.

*DISCUSSION:* The type is accompanied by a painting which shows it to be larger than anticipated based on the physical stature of the type. We agree with Smith and Stuntz (1958) that based on the anatomy of its pileipellis, the pileus should not be glabrous. Basidiospore fragility—their thin-walled and collapsed nature—is an important character in this species.

Pleurocystidia and cheilocystidia are scarce and did not revive well. *P. compressipes* belongs to section *Hispidoderma* .

***Pluteus deliquescens*** Murr., N. Amer. Fl. 10: 134. 1917. **Fig. 9.**

*ADDITIONAL DATA:* Basidiospores 6.6-7.2 x 6-6.8 µm. Pseudocystidia present between basidia, fragile and not reviving well. Pleurocystidia very few; 46-65 x 11.4-17 µm. Pileipellis composed of previously described elements (see Smith and Stuntz, 1958) and, embedded in a scant gelatinous matrix, some narrower hyphae with brown homogeneous pigment. Clamp connections occasional on pileipellis hyphae.

*TYPE: F. S. Earle 53*. Holotype, NY!. Very little of the specimen remains. Unsatisfactory.

*DISCUSSION:* Although we did not observe the clavate cheilocystidia noted by Smith and Stuntz (1958), we recorded larger spores and scattered clamp connections in the pileipellis. This species belongs to section *Hispidoderma* .

***Pluteus earlei*** Murr., Mycologia 3: 276. 1911. **Fig. 10.**

*ADDITIONAL DATA:* Basidiospores (4.8-)5.6-5.8 x 6.4-6.6(-8.4) µm. Cheilocystidia in fascicles; 20-23 x 11-13 µm, fusoid-ventricose, some rostrate, apex rounded to subacute, smooth, thin-walled, hyaline. Some clamp connections seen in the lamellar trama.

*TYPE: F. S. Earle and P. Wilson 1525*. Holotype, NY!. The pileipellis is parasitized by an imperfect fungus, and badly damaged. Unsatisfactory.

*DISCUSSION:* The cheilocystidia are smaller than but otherwise similar in shape to the pleurocystidia. Although the pileus context and lamellar trama as well as the thick-walled basidiospores are similar to those of P. *griseibrunneus* (see below), *P. earlei* differs by having much smaller cheilocystidia and a yellow rather than grayish brown pileus. It is clearly a distinct species in section *Hispidoderma.*

***Pluteus fibrillosus*** Murr., N. Amer. Fl. 10: 134. 1917. **Fig. 11.**

= P. cubensis (Murr.) Dennis, Bull. Soc. Mycol. France 69: 153. 1953.

*TYPE: F. S. Earle 129*. Holotype, NY!. Satisfactory.

*DISCUSSION:* We concur the Smith and Stuntz (1958) that some the apices of some pileipellis elements are incrusted with an amorphous material and that both cheilocystidia and pleurocystidia lack internal pigment. However, contrary to Smith and Stuntz (1958) and as noted by Singer (1956), most of the spores are subglobose. This species belongs to section *Hispidoderma.*

***Pluteus fuliginosus*** Murr., N. Amer. Fl. 10: 134. 1917. **Fig. 12.**

*ADDITIONAL DATA:* Basidiospores 6.6-7.6 x 5.4-6.4 µm. Basidia 14.6-18.2(-20) x 6.8-7.2 µm, usually 4-sterigmate but some 2-sterigmate. Some pleurocystidia with 1-4 apical to near apical, irregularly positioned, somewhat sterigma-like projections.

*TYPE: W. A. and E. L. Murrill 118.* Holotype, NY!. Satisfactory.

*DISCUSSION:* Although the unusually long basidia they describe were not observed, we concur with Smith and Stuntz (1958) that some pleurocystidia are pronged. The shape, irregular spacing, and number of these appendages clearly indicate that they are not sterigmata. This species belongs to section *Hispidoderma.*

***Pluteus fulvibadius*** Murr., N. Amer. Fl. 10: 136. 1917. **Fig. 13.**

*ADDITIONAL DATA:* Basidiospores 5.8-7.6 x 5.6-6.6 µm; inconspicuously angular to subglobose.

*TYPE: Murrill 760.* Holotype, NY!. Satisfactory.

*DISCUSSION:* We did not find the fusoid-ventricose cells reported in the pileipellis by Smith and Stuntz (1958). We agree with them that the pileipellis pigment is homogeneous and not amorphous as described by Singer (1956). Some basidiospores are definitely finely angular in outline, which is unique in *Pluteus.* According to Murrill (1917), the lamellae are approximate to the stipe. This type does not belong to the genus *Pluteus*, and should probably be placed in the family *Entolomataceae.*

***Pluteus glabrescens*** Murr., N. Amer. Fl. 10: 130. 1917. **Fig. 14.**

*ADDITIONAL DATA:* Basidia mostly 4-sterigmate, but some 2- sterigmate. Pleurocystidia not abundant; 41-53 x 11-16 µm. Pileipellis elements elongate-fusoid; 60-96.6(-119.6) x 10-25.2 µm.

*TYPE: F. S. Earle 1740.* Holotype, NY!. Very little of type remains. Unsatisfactory.

*DISCUSSION:* Based on its anatomical nature, we concur with Smith and Stuntz (1958) that the pileus cannot be glabrous. The presence of a few pleurocystidia with apical outgrowths is certainly distinctive. This species belongs to section *Hispidoderma.*

***Pluteus griseibrunneus*** Murr., N. Amer. Fl. 10: 133. 1917. **Fig. 15.**

*ADDITIONAL DATA:* Basidia 20-22 x 5-6 µm. Some pileus context hyphae appearing knotted, i.e., with occasional, enlarged, round to oval, thin-walled, intercalary cells.

*TYPE: F. S. Earle 71.* Holotype, NY!. Satisfactory.

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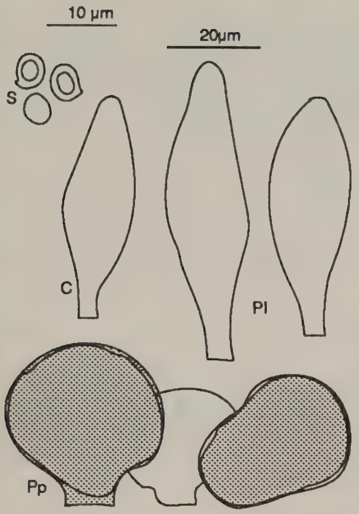
Figs. 7-12. Anatomical characters of *Pluteus* types. 7. *Pluteus campanulatus.* 8. *P. compressipes.* 9. *P. deliquescens.* 10. *P. earlei.* 11. *P. fibrillosus.* 12. *P. fuliginosus.* (C = Cheilocystidia; Pl = Pleurocystidia; Po = Pilocystidia; Pp = Elements of the pileipellis; S = Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures). Pp for *P. deliquescens* is not drawn to scale.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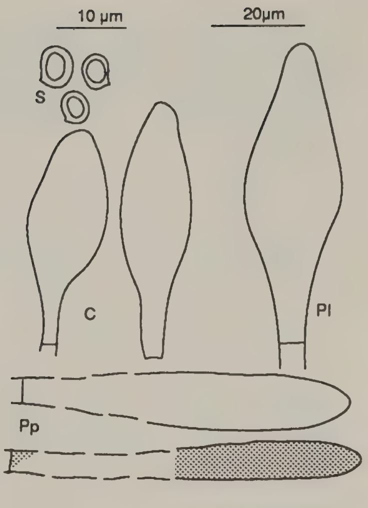
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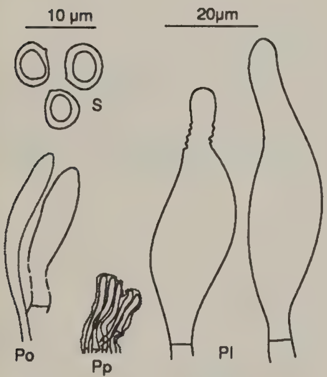
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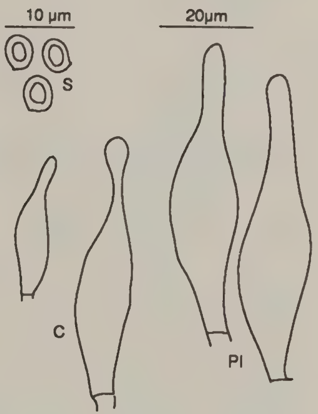
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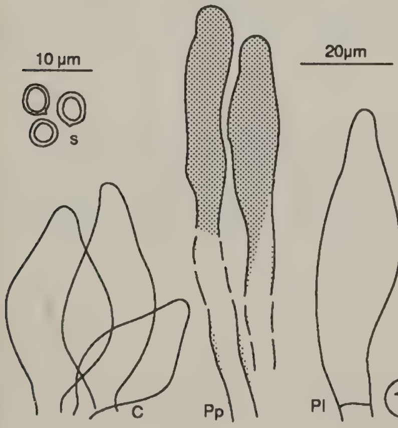
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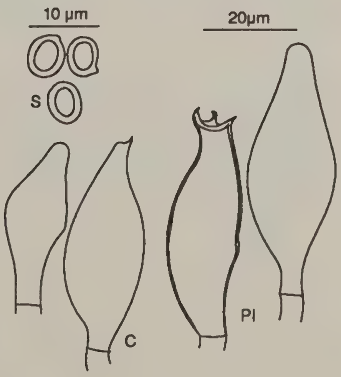
10 µm
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*DISCUSSION:* The wall thickness of some basidiospores is similar to those of *P. earlei* type (see *P. earlei* above). However, unlike *P. earlei*, *P. griseibrunneus* spores are without a conspicuous hilar appendix. The pinkish tint of the basidiospores under the 400X is a noteworthy character. The knotted hyphae (i. e., with round or oval intercalary cells) in the pileipellis are distinctive. This specimen belongs to section *Hispidoderma*.

***Pluteus jamaicensis*** Murr., Mycologia 3: 278. 1911. **Fig. 16.**

= *P. aethalus var. jamaicensis* (Murr.) Dennis, Bull. Soc. Mycol. France 69: 153.

*ADDITIONAL DATA*: Cheilocystidia 23-28 x 9-10 µm. Pileipellis elements clavate-vesiculose; 21.4-27.8 µm in diameter.

*TYPE: F. S. Earle 220*. Holotype, NY!. Satisfactory.

*DISCUSSION:* We found cheilocystidia similar to the ones reported by Smith and Stuntz (1958). Dennis (1953) relegated the taxon to the varietal level as *P. aethalus var. jamaicensis*. We have not examined *P. aethalus*, hence cannot comment on his judgement. However, *P. jamaicensis* sensu Murr. is distinct form *P. alachuanus* (see discussion on *P. alachuanus*). *P. jamaicensis* belongs to section *Celluloderma*.

***Pluteus latifolius*** Murr., N. Amer. Fl. 10: 135. 1917. **Fig. 17.**

*ADDITIONAL DATA:* Basidiospores thin-walled. Basidia 16.2-18.2 x 6.8-8 µm. Pleurocystidia 30-41.4 x 8-15 µm. Cheilocystidia 20-35 x 8-15 µm.

*TYPE: Murrill 510*. Holotype, NY!. Brittle, and very little remains. Unsatisfactory.

*DISCUSSION:* The pleurocystidia we measured are noticeably smaller than described by Smith and Stuntz (1958). Likewise, the basidiospore walls are thin rather than slightly thick-walled. This species belongs to section *Hispidoderma*.

***Pluteus lepiotiformis*** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 18.**

*TYPE: F. S. Earle 74*. Holotype, NY!. Almost destroyed but there are other collections by Earle from the same locality which could serve as a lectotype.

*DISCUSSION:* Singer (1956) did not report the cystidia as they were difficult to revive. We could not verify Smith and Stuntz's (1958) argument that "this species should show colored lamellar margins when fresh because of the many colored cheilocystidia" as paucity of the type material prevented us from studying a sufficient number of these cystidia. This species belongs in section *Hispidoderma*.

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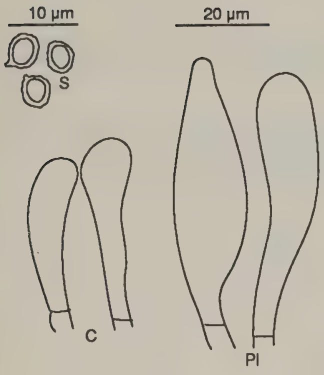
Figs. 13-18. Anatomical characters of *Pluteus* types. 13. *Pluteus fulvibadius*. 14. *P. glabrescens*. 15. *P. griseibrunneus*. 16. *P. jamaicensis*. 17. *P. latifolius*. 18. *P. lepiotiformis*. (C = Cheilocystidia; Kn = Knotted hyphae; Pl = Pleurocystidia; Pp = Elements of the pileipellis; S = Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures).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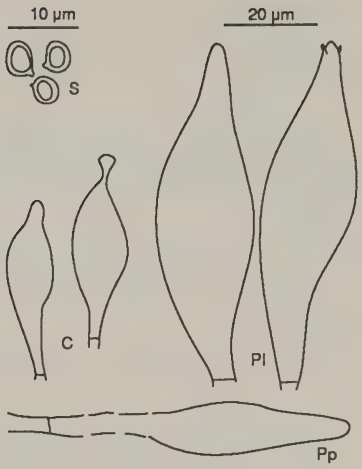
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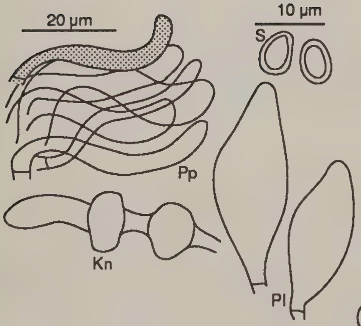
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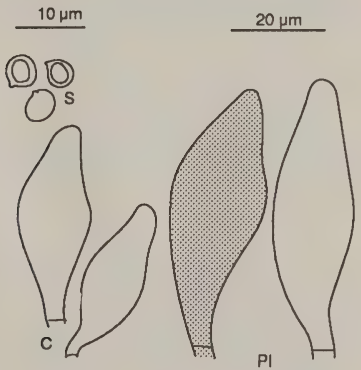
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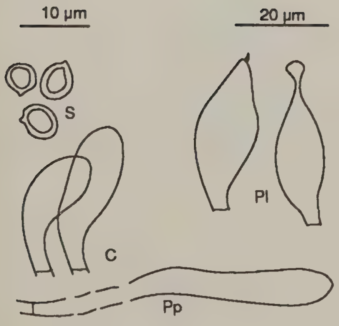
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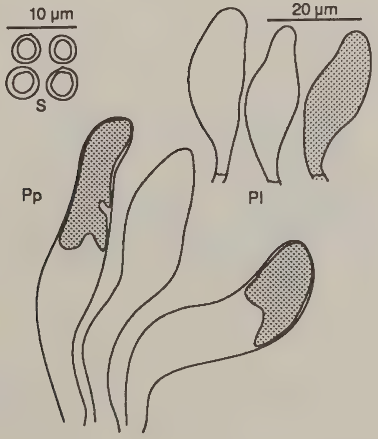
10 µm
S
Pp
20 µm
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⑱

**Pluteus longipes** Murr., N. Amer. Fl. 10: 133. 1917. **Fig. 19.**

*TYPE: F. S. Earle 628*. Holotype, NY!. Not well-preserved, difficult to revive. Unsatisfactory.

*DISCUSSION:* The pleurocystidia we observed were much smaller (32.2-50 x 9.2-12 µm) and sometimes provided with a single mucronate projection rather than one to five projections as described by Smith and Stuntz (1958). This species is in section *Hispidoderma*.

**Pluteus ludovicianus** Murr., N. Amer. Fl. 10: 133. 1917. **Fig. 20.**

*ADDITIONAL DATA:* Pleurocystidia with an apical mucilage cap with attached basidiospores.

*TYPE: F. S. Earle 130*. Holotype, NY!. Satisfactory.

*DISCUSSION:* The basidia are smaller than described by Smith and Stuntz (1958). Although Smith and Stuntz (1958) and Singer (1956) included this species in the *P. nanus* (Pers.: Fr.) Kumm. complex, the pileus of *P. nanus* is not prominently striate. The long striations on the pileus surface of *P. ludovicianus* are rather similar to *P. longistriatus* (Peck) Sacc. However, unlike P. *longistriatus*, *P. ludovicianus* has a rather wide and firm pileus (Murrill, 1917). *P. ludovicianus* is in section *Celluloderma*.

**Pluteus melleipes** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 21.**

*ADDITIONAL DATA:* Pleurocystidia with an apical mucilage cap. Some cheilocystidia are vesiculose to inflated-ventricose and 23-30 x 20-25 µm. Pileipellis elements forming a palisadoderm, 10.4-16.2 x 11.4-20.6 µm.

*TYPE: F. S. Earle 1589*. Holotype, NY!. Satisfactory.

*DISCUSSION:* Singer (1956) indicates a possible close affinity of this species with *P. chrysophaeus* (Schaeff.:Fr.) Quél., but Smith and Stuntz (1958) disagree because *P. chrysophaeus* does not have a yellowish stipe. Kühner and Romagnesi (1953), however, describe the stipe base of *P. chrysophaeus* as yellow. A lack of notes on odor and taste also makes a direct comparison difficult. According to Homola (1972), *P. melleipes* is similar to *P. lutescens* (Fr.) Bres. In our opinion, *P. melleipes* is not synonymous with but just similar to *P. chrysophaeus*. This species is in section *Celluloderma*.

**Pluteus melleus** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 22.**

= *P. admirabilis* (Peck) Peck.

*ADDITIONAL DATA:* Some pleurocystidia with an apical mucilage cap with a few attached basidiospores.

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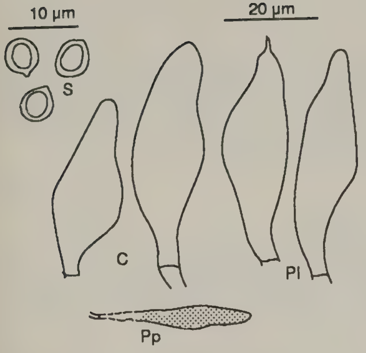
Figs. 19-24. Anatomical characters of *Pluteus* types. 19. *Pluteus longipes*. 20. *P. ludovicianus*. 21. *P. melleipes*. 22. *P. melleus*. 23. *P. multistriatus*. 24. *P. murinus*. (C = Cheilocystidia; Pl = Pleurocystidia; Pp = Elements of the pileipellis; S = Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures).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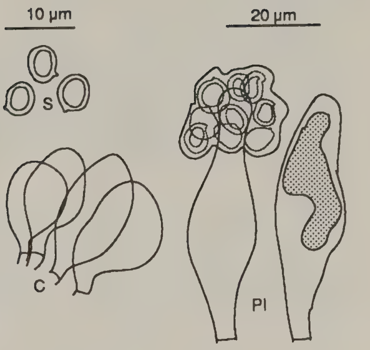
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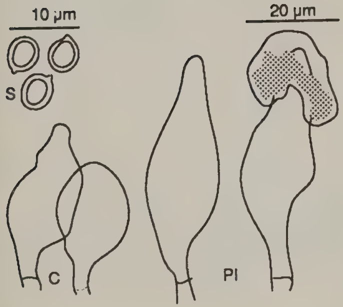
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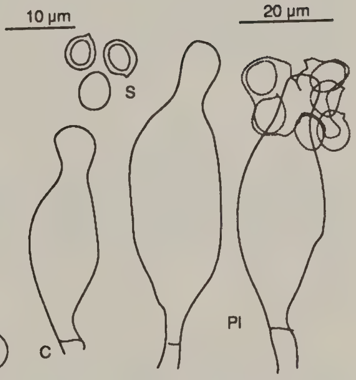
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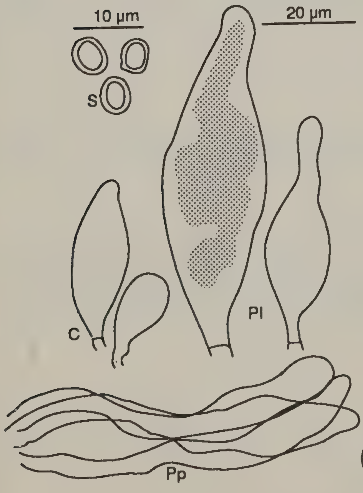
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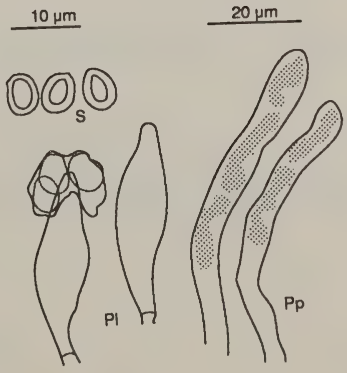
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*TYPE: Murrill 840.* Holotype, NY!. Just a damaged fragment of the type remains. Unsatisfactory.

*DISCUSSION:* Singer (1956) states that the pileipellis is not a palisadoderm and places this taxon near *P. flavofuligineus* Murr. in section *Hispidoderma.* However, both Smith and Stuntz (1958) and we found a palisade of vesiculose cells in the pileipellis. We agree with Smith and Stuntz (1958) that this species may be synonymous with or a color variant of *P. admirabilis* (Peck) Peck. This species is in section *Celluloderma.*

***Pluteus multistriatus*** Murr., Mycologia 3: 277. 1911. **Fig. 23.**

*ADDITIONAL DATA:* Basidia 25-32 x 8-9 µm. Pleurocystidia 35-90 x 8-30 µm; narrowly ventricose to pedicellate-ventricose, some with necks slightly tapered to long and narrow, apices broadly rounded to occasionally with a short narrow projection; hyaline to yellowish brown content within.

*TYPE: W. A. and E. L. Murrill 111.* Holotype, NY!. Satisfactory.

*DISCUSSION:* We could not demonstrate a hiatus that would clearly delimit the two forms of pleurocystidia described by Smith and Stuntz (1958). Instead, they appeared to all be part of one highly variable continuum. With its long striations on the pileus, the species has a superficial resemblance with *P. longistriatus.* However, *P. longistriatus* has a glutinous pileus and belongs in section *Celluloderma* while *P. multistriatus* is in section *Hispidoderma.*

***Pluteus murinus*** Bresad. Ann. Mycol. Berlin 53: 160. 1905. **Fig. 24.**

*DATA:* Basidiospores 5.2-8.0 x 5.8-6.8 µm; broadly ellipsoid; smooth; wall slightly thickened; hilar appendix not conspicuous. Basidia 22-28 x 6-8 µm; 4-sterigmate. Pleurocystidia 51-68 x 14-19 µm; broadly to narrowly fusoid-ventricose; apices subacute, with a mucilaginous apical cap; thin-walled; hyaline. Cheilocystidia not seen. Pileipellis elements of elongated hyphae with broad rounded end-cells; containing patches of brown pigment; 69-82 x 11.4-16.8 µm; wall slightly thickened (1.2-1.4 µm). Clamps not present.

*TYPE:* Europe. Holotype, NY!. Satisfactory.

*DISCUSSION:* Singer (1956) and Smith and Stuntz (1958) did not describe this type. The cracks on the pileus are distinctive. This species is darker and smaller than *P. cervinus,* and belongs to section *Hispidoderma.*

***Pluteus myceniformis*** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 25.**

*ADDITIONAL DATA:* Basidia 26-30 x 6-8 µm. Basidiospores 7.2-8.2 x 6-6.8 µm, without a conspicuous hilar appendix. Pleurocystidia 51-68 x 14-18 µm.

*TYPE: W. A. and E. L. Murrill 504.* Holotype, NY!. In satisfactory condition.

*DISCUSSION:* Although Smith and Stuntz (1958) suggested that a convex pileus with an incurved margin "indicates the aspect of *Collybia* rather than *Mycena*", Singer (1956) indicated that the habit is indeed somewhat mycenoid. This species is in section *Hispidoderma.*

**Pluteus nanellus** Murr., N. Amer. Fl. 10: 130. 1917. **Fig. 26.**

*ADDITIONAL DATA:* Basidiospores 5.8-7.2 X 4.8-6.2 µm. Cheilocystidia 30-48 x 12-17 µm. Pileipellis an intergrading hymenium layer composed of fusoid-ventricose elements with rounded apices, 90 x 24.6 µm, and clavate to vesiculose-pedicellate cells 23-34 x 18-18.4 µm.

*TYPE: W. A. and E. L. Murrill 73.* Holotype, NY!. Very little remains. Unsatisfactory.

*DISCUSSION:* Homola (1972) included *P. nanellus* as a synonym of *P. seticeps* (Atk.) Sing. based on the similarity of caulocystidia. Singer (1956) did not publish data from the type, but also considered this species to be a synonym of *P. seticeps*. The type of *P. nanellus* has a pileipellis of mixed intergrading pilocystidia and vesiculose-pedicellate cells and lacks pleurocystidia —a distinctive combination. Because *P. seticeps*, on the other hand, has both pleurocystidia and pilocystidia, *P. nanellus* should definitely be considered a separate species and not a synonym of *P. seticeps*. Based on the palisade layer in the pileipellis, lack of pleurocystidia and similar stature of their basidiomata, we believe *P. nanellus* is synonymous with *P. praerugosus* (see observations on *P. praerugosus*). *P. nanellus* is in section *Celluloderma.*

**Pluteus niveus** Murr., N. Amer. Fl. 10: 128. 1917. **Fig. 27.**

*ADDITIONAL DATA:* Basidia 13-22 X 5.4-8 µm. Cheilocystidia 30-48 x 10-14 µm. Pileipellis reviving poorly, elements filamentous with rounded end cells.

*TYPE: F. S. Earle 1698.* Holotype, NY!. Very little of the type remains. Unsatisfactory.

*DISCUSSION:* We agree with Smith and Stuntz's (1958) assumption that Singer's (1956) description is a composite of the type and another collection, because the pleurocystidia of the type are different from those Singer described. This species is in section *Hispidoderma.*

**Pluteus pallidicervinus** Murr., N. Amer. Fl. 10: 131. 1917. **Fig. 28.**

*ADDITIONAL DATA:* Basidiospores 6-7 x 4.8-6.2 µm. Basidia 16.6-22 x 5.8-6.2(8.2) µm. Pleurocystidia 34.4-42.6 x 13.8-17 µm; some with two to three, irregular, 2-2.8 µm long apical outgrowths at the obtuse apex.

*TYPE: F. S. Earle 1643.* Holotype, NY!. Satisfactory.

*DISCUSSION:* The presence of thin-walled pleurocystidia with apical outgrowths is a distinctive character in this species which belongs to section *Hispidoderma.*

**Pluteus praerugosus** Murr., Mycologia 12: 326. 1920. **Fig. 29.**

= *P. nanellus* Murr.

*DATA:* Basidiospores 6-6.8 x 5.4-6 µm; subglobose; smooth, with a conspicuous hilar appendix. Basidia 13.8-16.2 x 4.6-5.2(-5.8) µm; (2-)4-sterigmate. Pleurocystidia not seen even though hymenium was well-revived. Cheilocystidia in fascicles, very few seen; clavate-vesiculose; rather small, 18-26 x 7.8-10 µm; smooth; thin-walled; hyaline. Pileipellis elements a palisade of vesiculose-pedicellate cells with rounded apex (16.4-26.2 µm in diameter); content dark brown; a few pilocystidial elements seen, fusoid-ventricose (52-69 x 8-10.2 µm). Clamp connections not present. In the lamellar context, some delicate hyphae were seen intermixed with some rigid hyphae with bumpy outgrowths which could be called false clamps.

*TYPE:* Solitary, on a dead white oak log in Preston's Woods, Blacksburg, Virginia. July 16-31, 1920. *Murrill, s. n.* Holotype, NY!. Very little of the type remains. Unsatisfactory.

*DISCUSSION:* Murrill recorded globose basidiospores (5 µm in diameter). We found them to be subglobose rather than globose. Neither Singer (1956) nor Smith and Stuntz (1958) examined this type. This species is synonymous with *P. nanellus* (see discussion on *P. nanellus*), and belongs to section *Celluloderma*.

***Pluteus pulverulentus*** Murr., N. Amer. Fl. 10: 137. 1917. **Fig. 30.**

= *Pluteus aethalus* var. *pulverulentus* (Murr.) Dennis, Bull. Soc. Mycol. France 69: 153. 1953.

*ADDITIONAL DATA:* Pleurocystidia 36.6-42.8 x 12-17.8 µm; frequently with basidiospores adhering to the apical mucilage. Pileipellis elements 16.6-29.8 µm in diameter.

*TYPE: Broadway, s. n.* Holotype, NY!. Very little of the type remains. Unsatisfactory.

*DISCUSSION:* Dennis (1953) relegated the taxon to the varietal level. The presence of globose-subglobose basidiospores is a distinctive character. We did not find the mucronate cheilocystidia reported by Singer (1956). This species belongs to section *Celluloderma.*

***Pluteus reticulatus*** Murr., Mycologia 3: 276. 1911. **Fig. 31.**

*ADDITIONAL DATA:* Basidiospores 5.4-6.6 x 4.2-5.6(-6.2) µm, without a conspicuous hilar appendix.

*TYPE: Murrill 1159.* Holotype, NY!. Pileipellis is badly damaged and its elements are obscured by hyphae of an imperfect fungus. Type in unsatisfactory condition.

*DISCUSSION:* We do not agree with Smith and Stuntz (1958) that it "belongs in the *P. cervinus* group" because the pleurocystidia have acute apices and no ornamentation—they are rather of the magnus type. This species belongs to section *Pluteus.*

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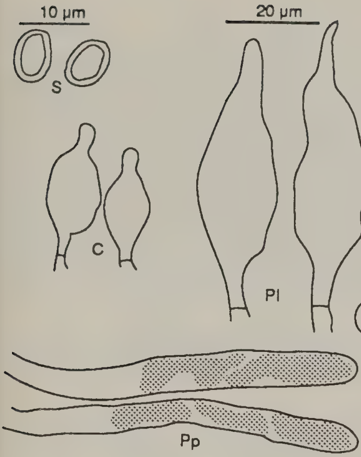
Figs. 25-30. Anatomical characters of *Pluteus* types. 25. *Pluteus myceniformis*. 26. *P. nanellus*. 27. *P. niveus*. 28. *P. pallidicervinus*. 29. *P. praerugosus*. 30. *P. pulverulentus*. ( C = Cheilocystidia; Pl = Pleurocystidia; Pp = Elements of the pileipellis; Po = Pilocystidia; S = Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures).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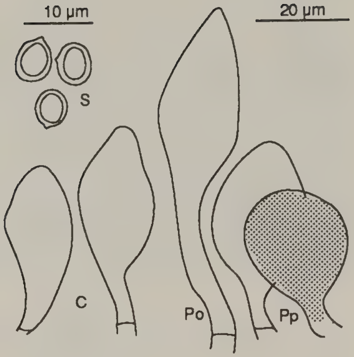
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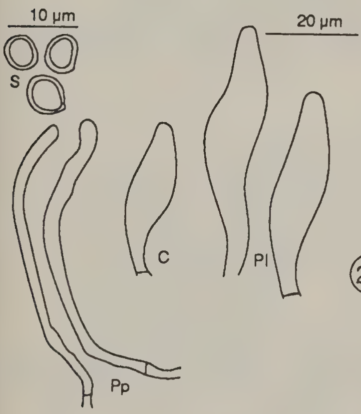
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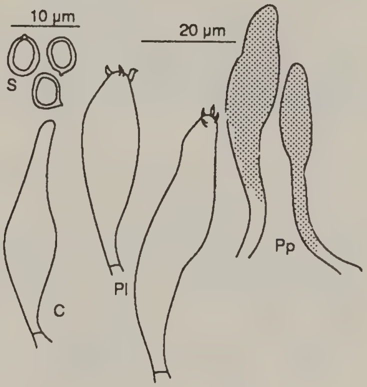
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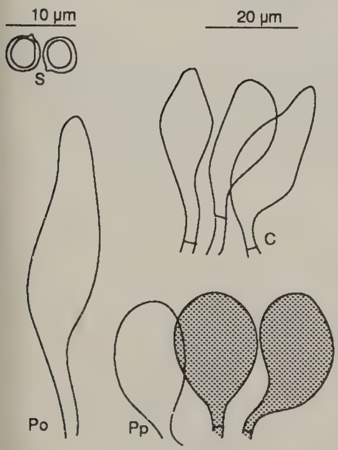
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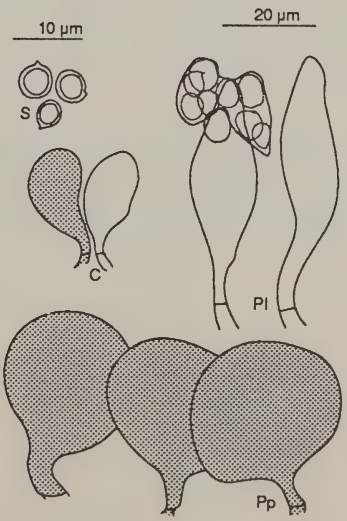
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**Pluteus rhoadsii** Murr., Bull. Torr. Bot. Cl. 66: 30. 1939. **Fig. 32.**

*DATA:* Basidiospores 4.6-5.2 µm in diameter, globose, smooth, thin-walled, some collapsing; with a conspicuous hilar appendix. Basidia 18-20.8 x (4.6-)5.2-5.8 µm, (2-)4-sterigmate. Pleurocystidia abundant, 41.4-52.2 x 12.6-15.8 µm, fusoid-ventricose with neck tapered to an obtuse or rounded apex which is sometimes provided with an apical mucilaginous cap, frequently with basidiospores adhering to it; few ampullaceous, all thin-walled, some collapsing, some with a brown content within. Cheilocystidia in fascicles, similar to pleurocystidia but smaller and with no mucilage or brown content, 26-36.6(-69) x 10-12(-22.8) µm, hyaline. Pileipellis of elongate upright-repent hyphae with acute to obtuse apices, end cells 57-92.6 x 12.8-19 µm; few acute-ended pilocystidia visible; both narrow and broad elements smooth and some with brownish content. Clamp connections not seen in pileipellis. Hymenial context with few scattered brown-pigmented hyphae.

*TYPE:* Densely gregarious to subcespitose, on a rotten oak log under oaks, Tung-oil Mill, Alachua Co., Florida. September 7, 1938. *Rhoads and Murrill, F 1810.* Holotype, FLAS!, isotype, NY!. Satisfactory.

*DISCUSSION:* Smith and Stuntz (1958) did not describe the type. The basidiospores were not reported as globose by Singer (1956). According to him, *P. rhoadsii* is synonymous with *P. fuliginosus* Murr., but we disagree. This is a separate species distinguished from *P. fuliginosus* by its globose spores. *P. rhoadsii* belongs to section *Hispidoderma.*

**Pluteus rimosus** Murr., Mycologia 3: 276. 1911. **Fig. 33.**

*ADDITIONAL DATA:* Basidiospores 4.8-5.2 x 4.4-5 µm. Pleurocystidia of two forms: (1) vesiculose-pedicellate; 22.8-31.6 µm; thin-walled, collapsing; hyaline; most common; (2) broadly fusoid-ventricose; 46.2-75.8 x 14.2-50.6 µm; collapsing, hyaline. Cheilocystidia similar to, but smaller than, pleurocystidia. Pileipellis a palisade of pedicellate-vesiculose cells with dark brown content, 16.2-28.6 µm in diameter.

*TYPE: Murrill 214.* Holotype, NY!. Satisfactory.

*DISCUSSION:* The small basidiospores and dimorphic pleurocystidia, in conjunction with the thick stipe, are distinctive characters. Singer (1956) suggested that this taxon may be synonymous with *P. reticulatus.* However, based on their pileipellis anatomy, they belong to two different sections—*Pluteus reticulatus* belongs to section *Pluteus* while *P. rimosus* belongs to section *Celluloderma.*

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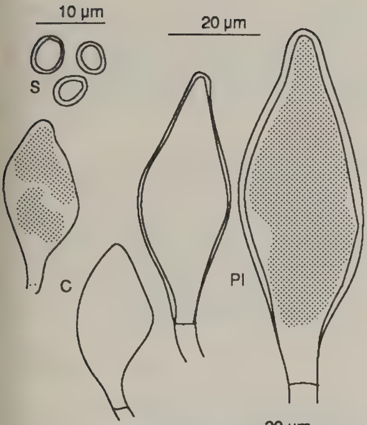
Figs. 31-37. Anatomical characters of *Pluteus* types. 31. *Pluteus reticulatus*; 32. *P. rhoadsii*; 33. *P. rimosus*; 34. *P. rugosidiscus*; 35. *P. spinulosus*; 36. *P. squamosidiscus*; 37. *P. umbrinidiscus.* (C = Cheilocystidia; Pl = Pleurocystidia; Pp = Elements of the pileipellis; S = Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures). Pp of *P. rugosidiscus* is not drawn to scale.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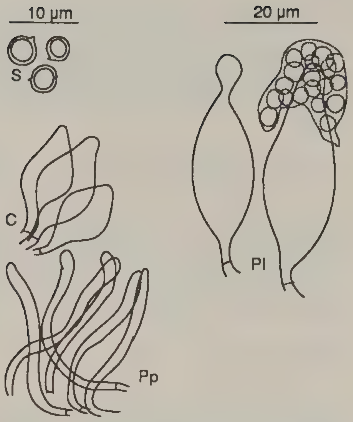
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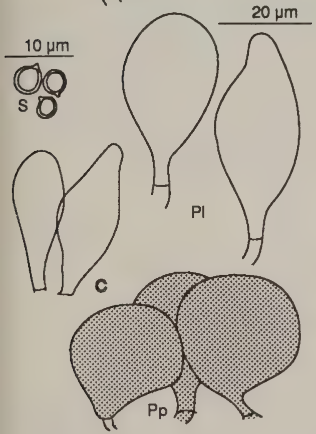
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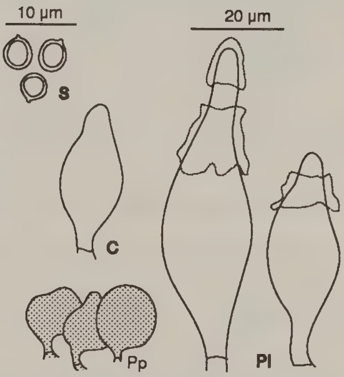
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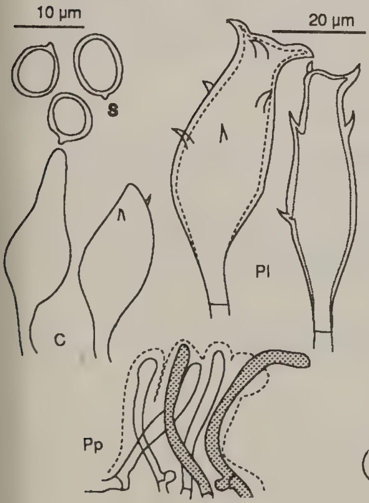
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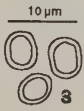
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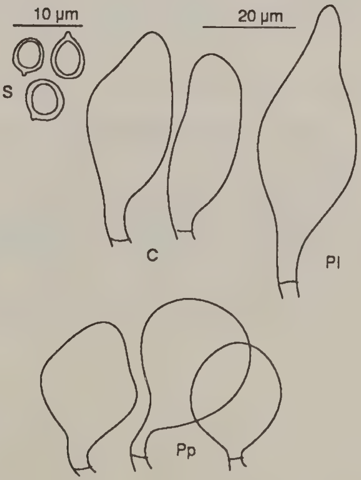
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**Pluteus rugosidiscus** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 34.**

*ADDITIONAL DATA:* Basidiospores 6-7 x 5.6-6.2 µm. Basidia 22-26 x 5.8-6.8 µm; few seen. Pleurocystidia up to 18 µm broad, some with an apical or subapical mucilage cap. Pileipellis a palisade of vesiculose-pedicellate cells with light yellowish content; 32-40 x 20-29 µm.

*TYPE: Murrill 111.* Holotype, NY. Type almost destroyed. Unsatisfactory.

*DISCUSSION:* The greenish-yellow pileus with a raised reticulate rugose disc is quite distinctive. The basidia were much smaller than reported by Smith and Stuntz (1958). This species is probably related to *P. admirabilis* because of their similarity in cap color and pleurocystidia. However, this species has rugose reticulate lines and a green tint to the pileus which *P. admirabilis* lacks. This species belongs to section *Celluloderma.*

**Pluteus spinulosus** Murr., N. Amer. Fl. 10: 138. 1917. **Fig. 35.**

*ADDITIONAL DATA:* Pileipellis a pellicle of narrow hyphae, 3.4-3.8 µm in width; end cells with round tips; some with a brownish content, some embedded in a gelatinous matrix.

*TYPE: M. E. Peck, s. n.* Holotype, NY!. The type is damaged by imperfect fungi. Unsatisfactory.

*DISCUSSION:* The type is distinctive by its clamp connections, marginate lamellae, large spores, lateral ornamentations on the pleurocystidia, and the variability of the pleurocystidia and cheilocystidia. This species belongs to section *Pluteus.*

**Pluteus squamosidiscus** Murr., N. Amer. Fl. 10: 130. 1917. **Fig. 36.**

*ADDITIONAL DATA:* Basidiospores without a conspicuous hilar appendix.

*TYPE: Earle 55.* Holotype, NY!. The type is damaged by imperfect fungi. Unsatisfactory.

*DISCUSSION:* The type was almost completely destroyed, and besides examining some basidiospores, we decided not to use it for anatomical observations. Neotypification is warranted for this species. Singer (1956) described larger basidiospores than reported by Murrill (1917) and recorded the pileipellis as composed of elongated hyphae without clamp connections. From the size of the pileus and the morphology of the pileipellis elements, this taxon seems to be in section *Hispidoderma.*

**Pluteus umbrinidiscus** Murr., N. Amer. Fl. 10: 130. 1917. **Fig. 37.**

*DATA:* Basidiospores 6.6-6.8 x 5.8-6.2 µm; ovoid-ellipsoid; with a conspicuous hilar appendix; smooth; some collapsing. Pleurocystidia 48.2-69 x 11.6-13.8 µm; pedicellate and

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Figs. 38-39. Anatomical characters of *Pluteus* types. 38. *P. unakensis*; 39. *P. whiteae.* (C: Cheilocystidia; Pl: Pleurocystidia; Pp: Pileipellis; S: Basidiospores. Scale lines: 10 µm for basidiospores; 20 µm for other structures).

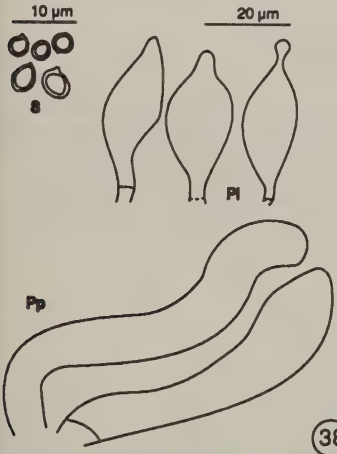
ventricose and tapered to an obtuse apex, sometimes ampullaceous; thin-walled; some cells with a faint yellow-brown content; a few slightly collapsed. Cheilocystidia few seen; clavate-ventricose with obtuse apices; smooth; hyaline; thin-walled. Pileipellis a palisade of mostly vesiculose-pedicellate to occasionally clavate-ventricose cells, all with broadly rounded apices; thin-walled; hyaline; 18.4-41.4 x 11.6-17.2 µm. Clamps connections lacking.

*TYPE:* In mixed woods, Unaka Springs, Tennessee. August 18-24, 1904. *W. A. and E. L. Murrill, s. n.* Holotype, NY!. Very little of the type remains. Unsatisfactory.

*DISCUSSION:* Smith and Stuntz (1958) did not study this type. Singer (1956) considers this species synonymous with *P. avellaneus* Murr. However, the nature of the pileipellis puts these species in two different sections: *P. avellaneus* in *Hispidoderma* , and *P. umbrinidiscus* in *Celluloderma.*

***Pluteus unakensis*** Murr., N. Amer. Fl. 10: 129. 1917. **Fig. 38.**

*ADDITIONAL DATA:* Basidiospores dimorphic; one form small, globose, 3.4-3.8 µm; second form oblong to ellipsoid; 4.2-5.2 x 5.2-5.8 µm; both forms smooth; with a conspicuous hilar appendix; wall slightly thickened. Pleurocystidia 26.8-34.6 x 10.2-12.2 µm. Cheilocystidia 18.4-41.4 x 11.6-17.2 µm. Pileipellis a turf of very large allantoid cells, 82.6-150 x 17-30 µm; most hyaline, occasionally with a fine yellowish granular internal content; a few very long (up to 380 µm) and narrow (9 µm broad) hyphae also present.



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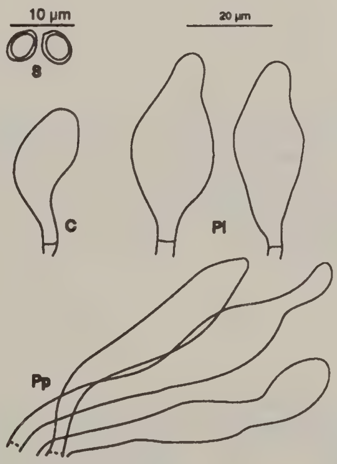

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*TYPE: Murrill 853.* Holotype, NY!. Very little of the type remains.

*DISCUSSION:* Although the basidiospores appear dimorphic, the smaller ones may merely be immature. Neither Singer (1956) nor Smith and Stuntz (1958) reported the yellowish content in cells of the pileipellis. The presence of very large allantoid pileipellis elements is quite distinctive. This species belongs to section *Hispidoderma*.

***Pluteus whiteae*** Murr., N. Amer. Fl. 10: 132. 1917. **Fig. 39.**

*ADDITIONAL DATA:* Basidiospores 6.6-6.8 x 5.2-5.8 µm, without a conspicuous hilar appendix. Pileipellis elements 85-126 x 23-34 µm; very elongate-fusoid with narrow necks and subacute to rounded apices; smooth; hyaline.

*TYPE: V. S. White 91.* Holotype, NY!. Brittle, and not much remains. Unsatisfactory.

*DISCUSSION:* In contrast to Smith and Stuntz (1958), the hymenium of this specimen did not rehydrate well. We did not see the slightly thickened, refractive parts of the cheilocystidia described by Smith and Stuntz (1958) which presumably correlate with the thin incrustations Singer (1956) reported in the form of pale melleous walls in some cystidia. Singer (1956) also reported larger pleurocystidia (74-79 x 27-32 µm) than those observed by us (39.2-45 x 11.6-16 µm). However, these data fall within the ranges of the two forms ("type 1" and "type 2" respectively) of pleurocystidia reported by Smith and Stuntz (1958) who noted that although both forms occur on some lamellae, other lamellae in the same basidioma may have only one of the two types. Due to the condition of the type and the quality of rehydration, good comparisons may be difficult to obtain with certainty. Pileipellis elements with acute tips, attributed to this species by Smith and Stuntz (1958), were not found. This species belongs to section *Hispidoderma*.

## ACKNOWLEDGMENTS

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# OBSERVATIONS ON SOME LITTLE KNOWN MACROFUNGI FROM JALISCO (MEXICO)

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## SUMMARY

Seven new records of macromycetes from Mexico were studied, four of them (*Galerina autumnalis*, *Lepiota alopochroa*, *Pluteus chrysophlebius* and *P. harrisii*) are reported for the first time from Mexico and the remaining (*Schizophyllum umbrinum*, *Hohenbuehelia angustata* and *Cystoderma fallax*) are new for the State of Jalisco mycobiota.

## INTRODUCTION

As part of the studies of the fungi from the State of Jalisco, Mexico, carry out by the authors, seven species of macrofungi not previously recorded from Jalisco are described. The present paper is based in the study of specimens deposited in the Herbarium of the Instituto de Botánica from the University of Guadalajara (IBUG); duplicates of them were sent to the Herbaria of Universidad Autónoma del Estado de Morelos (HEMIM) and Instituto de Ecología at Xalapa (XAL). The material studied was revised following the standard techniques in Mycology. When possible, color notations were made according to Kornerup & Wanscher (1989). The microscopic observations were made on slides mounted in 5% KOH and in some cases in Melzer's reagent, Congo Red and Cotton-Blue in Lactophenol.

## OBSERVATIONS ON THE STUDIED SPECIES

### Schizophyllaceae

*Schizophyllum umbrinum* Berk., Hook. Jour. Bot. 3: 15, 1851.

Figs. 1-3

This species is distinguished from other in the genus by the color (mustard yellow, 4B6 to yellowish, 4A5) and small size (3-5 mm diam.) of the basidiomata. Furthermore, it has spores (4.8-) 6-6.4 (-8.8) x 2.4-3.2 μm, subfusiform-elliptical and basidioles 16-32 x 4-8 μm, clavate, thick wall (1.6 μm). It differs from *S. leprieuri* Linder (Linder, 1933) because *S. umbrinum* presents not branched abhymenial hairs and lacks clamp conecctions. *S. umbrinum* is known from Mexico in tropical and subtropical forests (Guzmán, 1977) and from Guerrero (Linder, 1933).

EXAMINED SPECIMENS: JALISCO, Mpio. of Guadalajara, Barranca de Huentitán, km 1-2 road to Puente El Arcediano, Sept. 6, 1987, Vázquez 722 (IBUG, HEMIM, XAL); Sept. 19, 1989, Vázquez 918 (IBUG). Mpio. of Zapopan, Las Agujas, Nextipac, University of Guadalajara, Instituto de Botánica Campus, Jul. 20, 1990, Vargas 332; Oct. 8, 1990, Vargas 509 (IBUG).

### Tricholomataceae

*Hohenbuehelia angustata* (Berk.) Sing., Sydowia 5: 255, 1951.

Figs. 4-8

The species has a spathulate, petaloid to dimidiate pileus, whitish, light yellow (4A4, 4A3) to yellowish brown with reddish tones (7D5), glabrous to tomentose. Microscopically, it is distinguished by the size and form of the spores [4-5.6 x (2.4-) 3.2-4 μm, widely ellipsoid to ellipsoid]. The specimens studied agree with Singer & Digilio (1951) and Thorn & Barron (1986) descriptions. *H. angustata* is macroscopically very similar to *H. petalodes* (Bull. : Fr) Schulzer; however, the last one has bigger spores, (5-) 5.5-7.5 (-9) x (3-) 3.5-4.5 (-5.2) μm (Thorn & Barron, *op. cit.*). According to Herrera and Guzmán (1972) *H. angustata* was only known from the State of Oaxaca. This is the first report from Jalisco State.

EXAMINED SPECIMENS: JALISCO, Mpio. of Tapalpa, 5-15 km Tapalpa to Chiquilistlán road, Jul. 2, 1987, Guzmán-Dávalos 3852 (IBUG). Mpio. of Ciudad Guzmán, Nevado de Colima slopes, El Floripondio, Jul. 2, 1987, Guzmán-Dávalos 3824 (IBUG, XAL); Aug. 16, 1986, Guzmán-Dávalos 3497 (IBUG, HEMIM). Mpio. of Mazamitla, Guadalajara to Mazamitla road, km 17 before Mazamitla, Aug. 1990, Vargas 466 (IBUG).

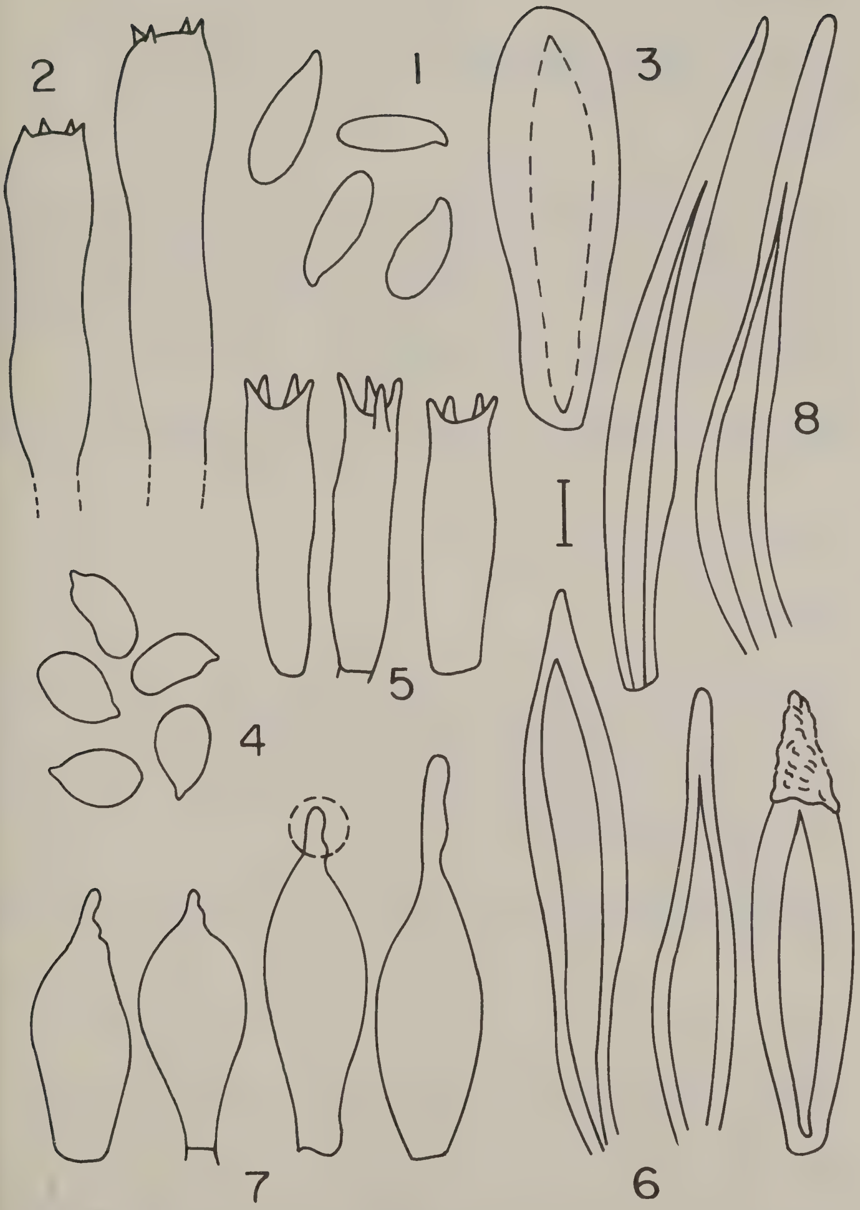

Fig. 1-8. 1-3: *Schizophyllum umbrinum* (Vázquez 722), 1: spores, 2: basidia, 3: basidiole. 4-8: *Hohenbuehelia angustata* (Vargas 466), 4: spores, 5: basidia, 6: metuloids, 7: cheilocystidia, 8: pileocystidia (Bar = 4 μm; except 6 = 8 μm).

## Pluteaceae

*Pluteus chrysophlebius* (Berk. & Rav.) Sacc., Syll. Fung. 5: 678, 1887.
= *P. admirabilis* (Peck) Peck, Ann. Rep. N.Y. State Mus. 38: 317, 1885.

Figs. 9-12

This species is characterized by its pileus vivid yellow (3A8) in fresh to yellowish brown (5B5) or dark brown (7F6) when dry; lamellae vivid yellow to pinkish-yellow (6A4-5A3) or salmon (7A4) when mature and stipe concolorous with the pileus. Microscopically, it is distinguished by subglobose spores [5.6-7.8 (-8) x 4.8-6.4 μm] and celullar epicutis. The studied specimen agrees with Singer (1958), Homola (1972), Pegler (1983) and Singer & Digilio (1951), in the last one as *P. admirabilis* (Peck) Peck. The species was known from U.S.A., Antillas and South America.

EXAMINED SPECIMEN: JALISCO, Mpio. of Tlajomulco de Zuñiga, N slope of Cerro Viejo, above Barranca del Caballito, Sept. 6, 1990, Vargas 500 (IBUG).

*Pluteus harrisii* Murr., Mycologia 3: 276, 1911.

Figs. 14-17

It is characterized by the pileus dark brownish gray (5F5), with nearly black center (8F2) and stipe whitish with grayish tones. Microscopically, it has spores (6.4-) 7.2-8. x (4.8-) 5.6-6.4 μm, widely ellipsoid, metuloid (40-) 68-76 (-100) x (13.6-) 16-22.6 μm, with 2-4 short and obtuse apical prolongations, and epicutis with postrate yellowish brown hyphae, with the apex atenuate, obtuse, rounded or inflated. The specimen studied agrees with Singer (1958) and Pegler (1983). *P. harrisii* was only known from Florida and Antilles.

EXAMINED SPECIMEN: JALISCO, Mpio. of Ciudad Guzmán, Nevado de Colima slopes, El Floripondio, Jul. 13, 1989, Vázquez 764 (IBUG, XAL).

## Agaricaceae

*Cystoderma fallax* Smith & Sing., Pap. Mich. Ac. Sc., Arts & Lett. 30: 116, 1945.

Figs. 18-20

It is distinguished by the scaly granulose surface of the pileus, presence of annulus and the basidioma color, brown-yellow, brownish orange or rust brown (6C8, 6E8); microscopically it is defined by the amyloid spores, (3.6-) 4-4.8 x 2.8-3.2 μm,

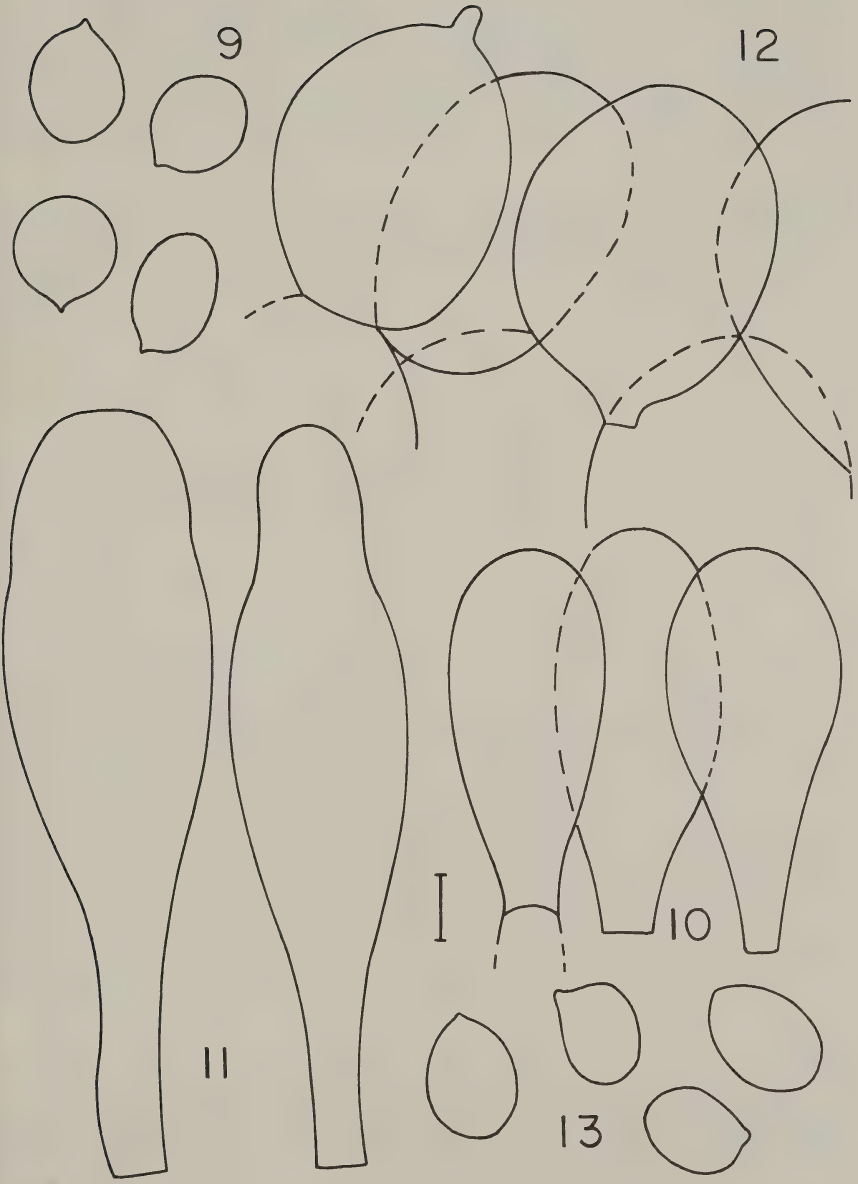

Fig. 9-13. 9-12: *Pluteus chrysophlebius* (Vargas 500), 9: spores, 10: cheilocystidia, 11: pleurocystidia, 12: epicutis cells, 13: *P. harrisii* (Vázquez 764), 13: spores (Bar = 4$\mu$m; except 10 & 12 = 8 $\mu$m).

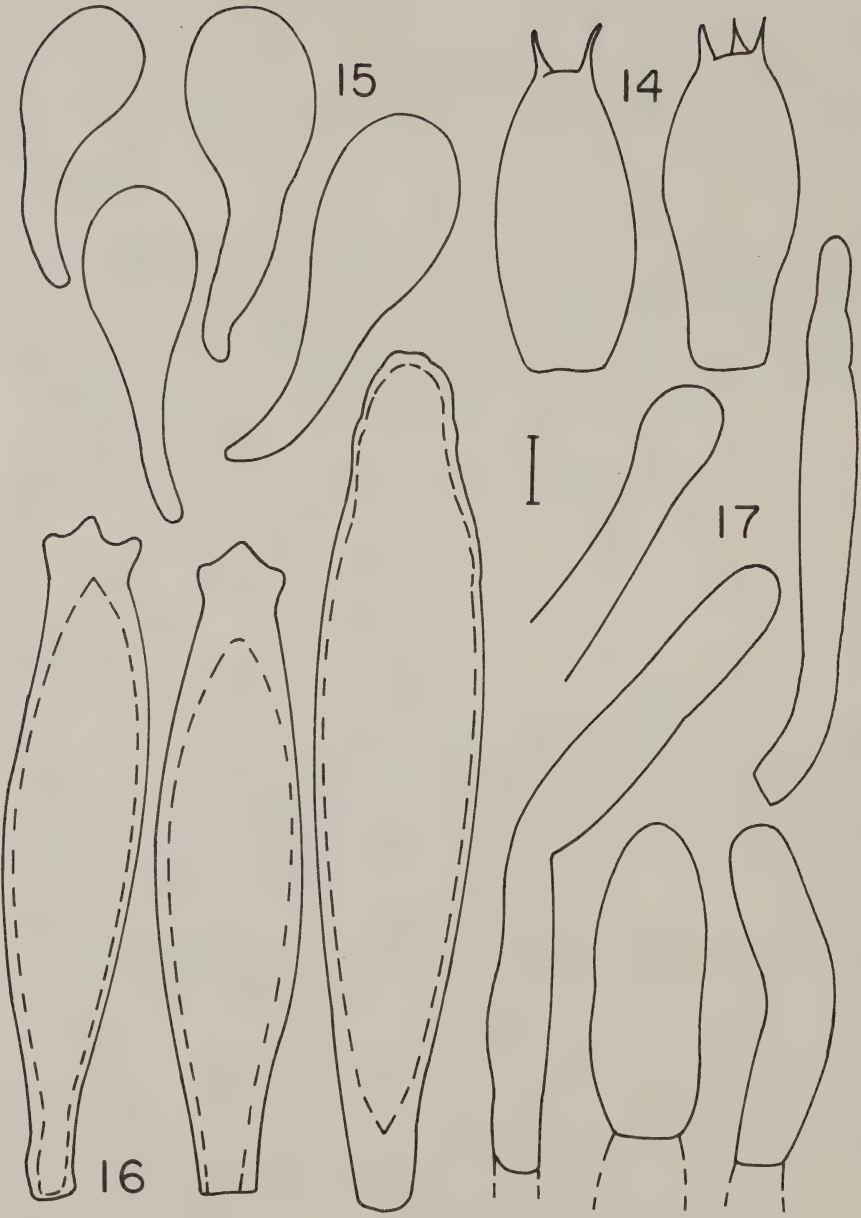

Fig. 14-17: *Pluteus harrisii* (Vázquez 764), 14: basidia, 15: cheilocystidia, 16: pleurocystidia, 17: epicutis cells (Bar = 4 $\mu$m; except 14 = 4 $\mu$m).

and wall color (reddish orange) of the epicutis elements. It is near to *C. amianthinum* (Scop. : Fr.) Fayod, which lacks annulus and has spores larger than 5 μm long. The studied specimens agree with Smith & Singer (1945) and Guzmán (1977). This species is known from Hidalgo, Durango, Tlaxcala and Valley of Mexico (Frutis & Guzmán, 1983; Quintos *et al.*, 1984; Santiago-Martínez *et al.*, 1990; Guzmán & Guzmán-Dávalos, 1992). This is the first report from Jalisco.

EXAMINED SPECIMENS: JALISCO, Mpio. of Mazamitla, Sierra de Mazamitla, Club Campestre Los Cazos, Oct. 2, 1988, Cárdenas 35 (IBUG). Mpio. of Tecalitlán, Sierra del Halo, km 18 Tecalitlán to Jilotlán road, Aug. 28, 1988, Guzmán-Dávalos 4350 (IBUG).

*Lepiota alopochroa* (Berk. & Br.) Sacc., Syll. Fung. 5: 63, 1887.
=*Lepiotula alopochroa* (Berk. & Br.) Horak, New Zealand J. Bot. 18: 185, 1980.

Figs. 21-24

This species is distinguished by the pileus brownish orange or rust brown (6D7, 6C8) and the stipe reddish brown to whitish near the apice, characteristics common to *Lepiota castanea* Quél. (Horak, 1980-B), being different because *L. alopochroa* has smaller spores, 7.2-9.6 x 3.2-4.4 μm, subcylindrical and spurred. The specimens examined agree with Horak (1980-A & 1980-B) and Pegler (1972) descriptions. The pileus surface in Luquin s.n. and Vargas 540 materials is cracked, making visible the whitish context, characteristic not mentioned by Horak and Pegler, and not seen in specimen Vázquez 561. This species, together with others, was included in the genus *Lepiotula* by Horak in 1968, because of its hymeniform cuticle, spurred and dextrinoid spores, free lamellae and membranous annulus, but Horak (1980-B) transfered it again to *Lepiota*, considering this genus with a wide morphologic range of variation. *Lepiota alopochroa* was only known from Brazil, New Zealand, India and Sri Lanka (Guzmán & Guzmán-Dávalos, 1992) and now it is reported for the first time from Mexico.

EXAMINED SPECIMENS: JALISCO, Mpio. of Zapopan, Las Agujas, Nextipac, University of Guadalajara, Instituto de Botánica greenhouse, Aug. 4, 1987, Luquin s.n. (IBUG); Facultad de Agronomía Campus, Aug. 14, 1987, Vázquez 561 (IBUG). Mpio. of Cd. Guzmán, Nevado de Colima slopes, El Floripondio, Sept. 16, 1991, Vargas 540 (IBUG, XAL).

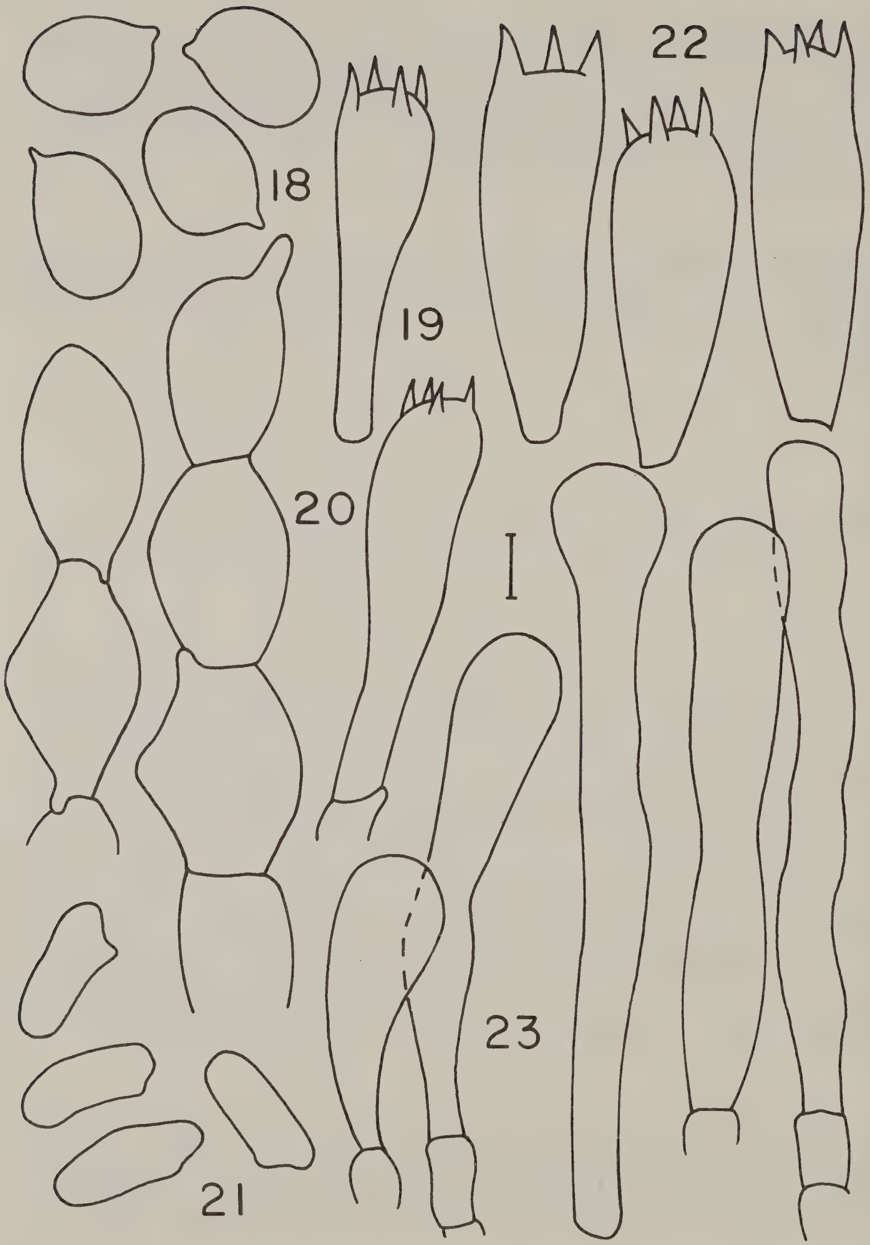

Fig. 18-23. 18-20: *Cystoderma fallax* (Cárdenas 35), 18: spores, 19: basidia, 20: epicutis cells. 21-23: *Lepiota alopochroa* (Luquin s.n.), 21: spores, 22: basidia, 23: cheilocystidia (Bar = 4 μm; except 18 = 2 μm, 20 = 8 μm).

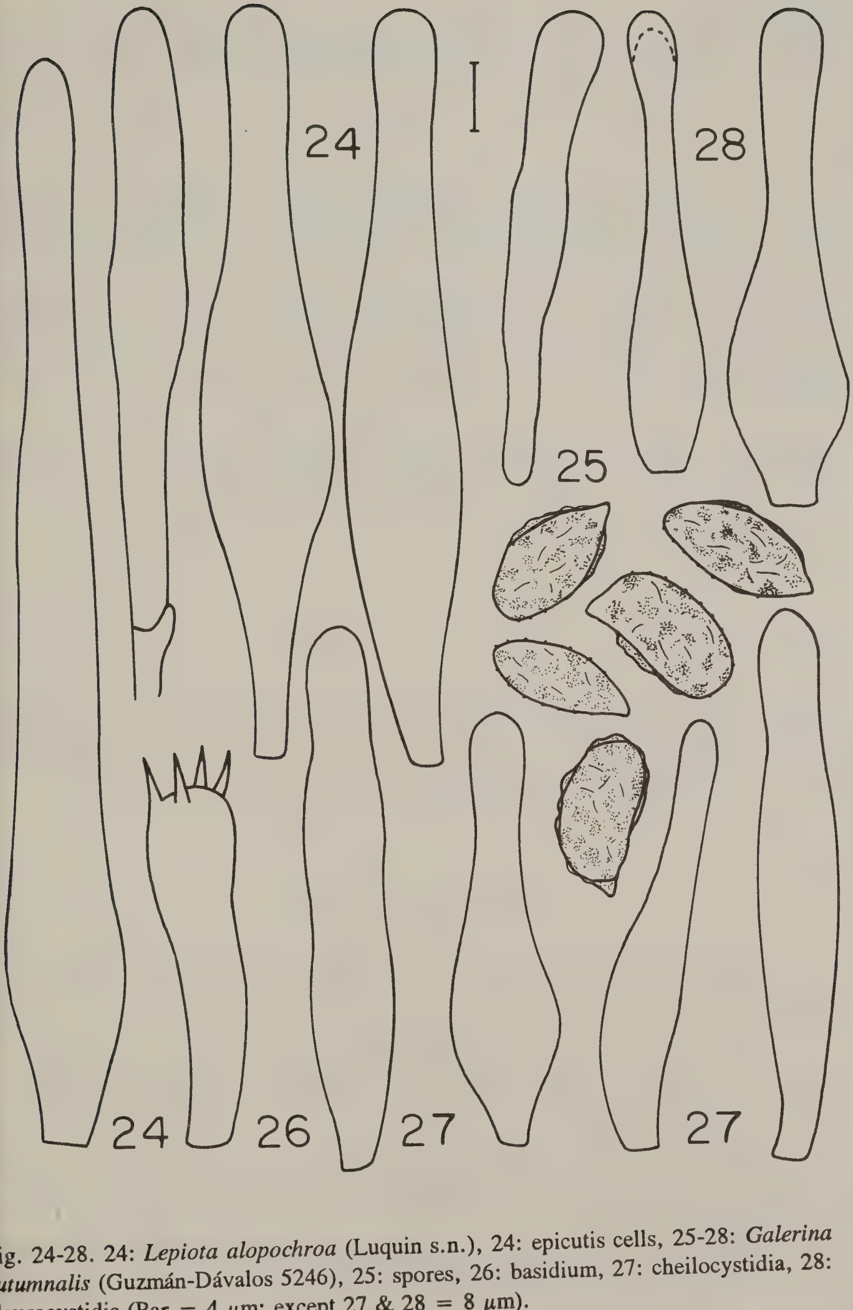

Fig. 24-28. 24: *Lepiota alopochroa* (Luquin s.n.), 24: epicutis cells, 25-28: *Galerina autumnalis* (Guzmán-Dávalos 5246), 25: spores, 26: basidium, 27: cheilocystidia, 28: pleurocystidia (Bar = 4 µm; except 27 & 28 = 8 µm).

Cortinariaceae

*Galerina autumnalis* (Peck) Smith & Sing., Monograph on the genus *Galerina* Earle: 246, 1964.

Figs. 25-28

This species is defined by its yellowish brown (5B7) to ochraceus brown (5D8), smooth, subviscid and hygrophanous pileus, yellowish brown with reddish tinges stipe with a dark base and a submembranous well defined annulus. Furthermore, it presents a gelatinized epicutis and pleurocystidia and cheilocystidia 44-66 x 4-16 $\mu$m, subcylindrical or ampullaceus with a thin and large neck and the apex rounded, obtuse to attenuate. The specimen agrees with Smith & Singer (1964). *G. autumnalis* is deadly poisonous (Lincoff, 1977) and was only known from North America (not Mexico) and Europe.

EXAMINED SPECIMEN: JALISCO, Mpio. of Tapalpa, km 7.5 La Frontera to Juanacatlán road, Oct. 15, 1990, Guzmán-Dávalos 5246 (IBUG, XAL).

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# AMANITA PACHYSPERMA, AMANITA SUBVIRGINIANA, AND AMANITA VIRGINIANA (TAXONOMY AND DISTRIBUTION) WITH NOTES ON DESCRIPTION OF THE LAMELLA TRAMA IN AMANITA

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## Summary

*Amanita pachysperma* and *A. virginiana* are described based on their holotypes and recently collected or recently located material. Known ranges of the two taxa are expanded. *Amanita subvirginiana* is known only from its holotype of which a study is reported. A collection apparently once intended by Singer to be the type of *A. biovigera* was located; it is assignable to *A. pachysperma*. A lectotype of *A. biovigera* must be selected from Bresadola's collections labeled "*A. strangulata*", an entity with 4-sterigmate basidia. Illustrations of the taxa treated are provided for the first time. A key is provided for taxa in *Amanita* section *Vaginatae* that have plentiful to dominant bisterigmate basidia and small, fragile basidiocarps. There is provided a discussion of useful terms and methodology with regard to the analysis and description of the lamella trama in *Amanita*.

## INTRODUCTION

The small set of taxa in *Amanita* section *Vaginatae* (Fr.) Quél. that have plentiful to dominant bisterigmate basidia and small, fragile basidiocarps were discussed briefly by Tulloss (1989); such taxa are known at present only from the eastern U.S.A. Prior to the work reported herein, three taxa had been demonstrated to belong to this group——*A. pachysperma*, *A. virginiana*, and *A. ristichii* Tulloss. *Amanita subvirginiana* (known only from the single specimen of the holotype) must be added.

*Amanita pachysperma* was known until now only from the holotype collection made in North Carolina. Recently made or recently located, well-documented collections provide the opportunity for a more detailed treatment of this species and an extension of its known range to Connecticut, eastern Massachusetts, New Jersey, and Rhode Island.

*Amanita virginiana* has been known in some detail only from its holotype (collected in Virginia); it has been reported recently from Pennsylvania (Jenkins, 1986), Illinois (Began, 1988), and Kentucky (Branson, 1990). A number of recent, well-documented collections require a revision of the limits of the known range of this species. It extends from Illinois and Kentucky north and east to New Jersey, New York, and eastern Massachusetts.

At the end of this article, a key is provided for the four taxa of section *Vaginatae* known to have a small basidiocarp and plentiful to dominant bisterigmate basidia.

## MATERIALS AND METHODS

Methods, terms, abbreviations, and presentation of data on basidiospores follow Bas *et al.* (1988) and Tulloss *et al.* (1992) except as described in this section and the following two. All tissues examined were from exsiccata and were pale yellowish in 3% KOH unless otherwise stated.

Color codes of the form ''11D2'' are from (Kornerup & Wanscher, 1978). Color codes of the form ''7.5YR 8/6'' are from (Munsell Color, 1975). Color names in italics with the first letter of each word capitalized are from (Ridgway, 1912).

Phenoloxidase spot tests on *A. virginiana* were carried out using the method of Marr (1979) and Marr *et al.* (1986).

With one exception (RET), the herbarium name abbreviations used in this paper follow (Holmgren *et al.*, 1990).

CUP - Plant Pathology Herbarium, Cornell University, Ithaca, New York, U.S.A.
CUP-A - G. F. Atkinson Herbarium, separately accessioned in CUP
F - Herbarium of the Field Museum of Natural History, Chicago, Illinois, U.S.A.
FH - Farlow Reference Library and Herbarium of Cryptogamic Botany, Harvard University, Cambridge, Massachusetts, U.S.A.
FLAS - Herbarium, University of Florida, Gainesville, U.S.A.
L - Rijksherbarium, Leiden, The Netherlands
MICH - Herbarium, University of Michigan, Ann Arbor, U.S.A.
NCU - Herbarium, Biology Department, University of North Carolina, Chapel Hill, U.S.A.
NY - Herbarium of The New York Botanical Garden, Bronx, U.S.A.
RET - personal herbarium of the author
S - Herbarium, Botany Department, Museum of Natural History, Stockholm, Sweden
SIU - Herbarium, Plant Biology Department, Southern Illinois University, Carbondale, U.S.A.

The abbreviation ''Twp.'' stands for ''Township''.

## SOME COMMENTS ON TERMINOLOGY AND TYPOGRAPHY

For some time I have been concerned with the ambiguous use of the ''plus or minus'' symbol in mycological writings and have diverged from common usage in order to avoid the ambiguity, but have not discussed the matter. Mycologists use $\pm x$ (where $x$ is a number) both to mean "approximately $x$" and to indicate a range (*e.g.*, $y \pm x$, indicating the range $y-x$ to $y+x$). Since the latter usage is very widely accepted in science, I reserve the "±" for this purpose. There is no reason to give up the symbol in the other context, but it must take a different textual position with regard to the number it modifies. I have chosen to place it to the right of the modified number in the superscript position. In this position with relation to a number $x$, "$x^{\pm}$", "$x^{+}$", and "$x^{-}$" can all have consistent meanings—respectively "approximately $x$", "$x$ or more", and "$x$ or less".

After recent correspondence and discussions with Dr. Bas, I have made three changes in terminology to which I call attention. The term "vascular hyphae" as defined in Bas *et al.* (1988) has replaced "oleiferous hyphae". "Acrophysalides" is now used with reference to terminal, inflated cells of both pileus and stipe contexts. Since, the term "acrophysalidic" is properly used for more than one tissue in *Amanita*, the stipe tissue typical of the genus will be called "longitudinally acrophysalidic".

## DESCRIPTION OF THE LAMELLA TRAMA IN AMANITA

In analysis of a number of taxa of *Amanita* from Andean Colombia, Tulloss *et al.* (1992) placed considerable emphasis on the form of the subhymenium and the angle of divergence from the central stratum of terminal, inflated cells and basal elements of the subhymenium. Attention to these often neglected characters provided an apparently sound means of distinguishing taxa that, almost certainly, would not have been so clearly distinguishable otherwise. My methods in preparing the anatomical studies for the cited article were workable as far as they went, but now appear overly simplistic; and these methods have undergone additional development in the past year. The improvements have been largely thanks to provocative correspondence and discussion with Dr. C. Bas, Rijksherbarium, Leiden, the Netherlands. As a consequence of all this, I undertake here to review the terminology and form of description of the lamella trama and subhymenium that I favor currently.

My observations have been made on exsiccata of mature material or material that was rather close to initiation of sporulation when it was dried. The observations are made on transverse sections of portions of lamellae selected from the region about halfway between the stipe and the pileus margin. Material to be examined is rehydrated in 2-3% KOH, with gentle heating if deemed necessary; however, often allowing several minutes for rehydration makes heating unnecessary. In any case, rehydration of the central stratum of the lamella trama is often not fully achieved. The sections are made freehand—when possible with the aid of a dissecting scope, but often by placing a thumb tip over a piece of lamella with the axis of the thumb aligned with the longer dimension of the lamella and achieving very closely spaced cuts by slowly increasing pressure of the side of the cutting razor against the thumb tip. This can provide surprisingly successful results with a minimum of equipment.

In the most commonly accepted use of the words "lamella trama", the phrase applies to the set of all tissues between the bases of basidia on opposing faces of a lamella (*e.g.*, see Snell & Dick (1971): 169). In all my previous publications (*N.B.*!) I have used the term in a more restricted sense excluding the subhymenium. Dr. Bas has convinced me to revert to the more common usage; and I do so beginning with the present paper. Nevertheless, I find it useful to have a term for the lamella trama less the subhymenium; and so I will introduce the term ''core trama'' (or ''c-trama'') to apply to the central stratum *plus* the region (if such exists) on either side of the central stratum that is occupied by terminal, inflated cells [the ''pressure cells'' of Bas (1969: 325-326)]. Note that when no divergent, terminal, inflated cells are present in the lamella trama, the c-trama is equivalent to the central stratum; and I choose not to confuse matters by using the new term when ''central stratum'' will serve and is accurate.

The most significant terminological problem arises when one wishes to treat that portion of the trama that diverges from the central stratum and terminates by giving rise to the hymenium. Bas (1969: 327, Fig. 11) called this the ''subhymenial tree''. I adopt this as a technical term. As pointed out by Reijnders & Stalpers (1992: 71), the subhymenial tree appears to be all one structural/functional unit; and the set of these trees might properly be called (in its entirety) ''subhymenium''. However, this latter term has a different usage historically. Particularly, if we look at usage relative to *Amanita* since the seminal monograph of Bas (1969), the term has been applied to an apparently compact layer of small cells below the basidia and basidioles. It would create a confusing discontinuity in the modern literature to grossly alter the use of the term. The subhymenial tree is a convenient, although until now informal, term with which to refer to a single, complete, branching unit of the tissue of interest. When I refer to divergent elements of the trama exclusive of divergent, terminal, inflated cells, I refer to the basal portion of the overlapping, subhymenial trees (*i.e.*, to their ''trunks and lower branches''). I will call this region the ''subhymenial base''.

Difficulties remain. Not the least of these is the issue of delimiting the ''upper branches'' from the ''lower branches'' of the subhymenial tree. The classical picture of a cluster of small cells of various sizes and shapes at the end of uninflated branches is only representative of one of many forms for the subhymenial tree in *Amanita*. Indeed, the subhymenial base may consist of inflated cells while the subhymenium comprises entirely *uninflated* hyphal segments. On the other hand, there is, in some species, very little difference in form between cells of the subhymenial tree nearest the basidia and those cells nearest the central stratum. There are also cases in which the subhymenial tree is greatly reduced——perhaps to a single, small cell per each one or two hymenial elements. Such a cell may be barely divergent from the central stratum. In ''nonclassical'' cases, what terms are to be used? It is my impression that there is no consistent answer presented by the literature. In the highly reduced case, I choose to apply ''subhymenium'' to the set of cells that directly give rise to basidia or basidioles. In all cases, I take a consistent approach of writing my description of the entire subhymenial tree in two parts——describing it from the bases of basidia and basidioles toward the central stratum under the heading ''SUBHYMENIUM'' and from the central stratum toward the basidia and basidioles under the heading ''LAMELLA TRAMA''. For several years, I have made it my practice not to attempt such a description without drawing the tissue after close observation at 1000x. Often, a first impression is misleading, and drawing is corrective.

When relatively plentiful, divergent, terminal, inflated cells are present in the trama, I use the term ‘‘exposed subhymenium’’ to refer to the portion of the subhymenial trees that is seen to exceed the outermost limit of the c-trama. When no or few divergent, terminal, inflated cells are present in the trama, the term is not used. Reijnders & Stalpers (1992: 4) have pointed out the problems with, and confusion surrounding, the term ‘‘hymenopodium’’. I have chosen to avoid the use of it.

Since, there is some variation in the angle at which base elements of the subhymenial tree diverge from the central stratum, it is worth noting such angles. When I use the term ‘‘angle of divergence’’ I am refering to the angle (with its opening toward the edge of the lamella) made by a diverging element with the central stratum.

The lamella trama of *Amanita* is usually unhesitatingly labeled ‘‘bilateral’’, and illustrations commonly depict a canonical form for such a trama (Fig. 1)—a distinct central stratum from which diverge at rather marked angles terminal, inflated cells and ramifying elements of the subhymenial tree. This picture is over simplified—even when limited to the mature lamella trama. Reijnders & Stalpers (1992: 3) state erroneously that the presence of terminal, inflated cells is a constant feature of the *Amanita* trama. Indeed, terminal, inflated cells may be missing [as noted by Bas (1969: 326, Figs. 31 & 51)] or obscured through embedding in the central stratum. In the latter case, they may be confused with intercalary, partially inflated or inflated cells of the central stratum. Sometimes careful attention is required to see if divergent, inflated cells are intercalary in the subhymenial base or are terminal. For example, see the detailed illustration of the lamella trama of *A. citrina* (Schaeff.) Pers. in (Douwes & von Arx, 1965: 203, Fig. 7). Some other examples of noncanonical *Amanita* trama follow:

- the subhymenium may be reduced to rather short hyphal elements branching away from a bulky central stratum—what might be called a ‘‘subregular trama’’ (Fig. 4)

- the subhymenium may contain inflated or partially inflated elements with very diverse distributions (Tulloss *et al.*, 1992: 33, Figs. 21 & 24) or lack such elements entirely (Fig. 3)

- the angle of divergence of elements of the subhymenial base and/or terminal, inflated cells from the central stratum may range from very shallow (Tulloss *et al.*, 1992: 33, Fig. 24) to a right angle (Bas, 1969: 324, Fig. 17)

- branching in the subhymenium may produce numerous elements that extend to some length in a direction *away* from the lamella edge—thus giving an impression of an inverse trama in some localities (Bas, 1969: 324, Fig. 17)

- branching of subhymenial trees and interweaving in the subhymenial tree may occur to such a degree as to leave no impression of smooth divergence from the central stratum—a situation rather difficult to draw accurately, but somewhat suggested schematically by Fig. 2.

I have formed the opinion that the structures one observes in the lamella trama are species specific and of significant taxonomic value after extensive examination of the following: types of all North American taxa in *Amanita* section *Amidella* (E. J. Gilb.) Konr. & M. (including new species that I will propose in a future publication); types of all North American, white species of *Amanita* section *Phalloideae* (Fr.) Quél.; types of more than two dozen taxa of *Amanita* section *Vaginatae* described since 1940; the 13 taxa (12 types reviewed) described from Andean Colombia (including taxa of all sections except section *Amidella*); and diverse other taxa or apparent taxa from India, Nepal, Japan, Australia, Argentina, Colombia, Europe, and North and Central America. These studies include taxa in all six sections of *Amanita* accepted by Corner & Bas (1962). Dr. David T. Jenkins (pers. comm.), Birmingham, Alabama, has formed a similar opinion in his studies of *Amanita* in North America——especially in his unpublished work on section *Vaginatae*.

Bas (1969: 326-327, Figs. 11-17) recorded the form of the subhymenium of the taxa of *Amanita* section *Lepidella* using a number of terms including ''cellular,'' ''subcellular,'' ''coralloid,'' ''ramose,'' ''inflated ramose,'' etc. While noting some variation within species, Bas (1969) implicitly presents the structure of the subhymenium as a character useful in distinguishing taxa and mentions the structure in every description based on material in which he was able to rehydrate and observe the tissue. In my first attempts at employing the structure of the lamella trama as an important character, I fixed upon the structure of the subhymenium (following Bas) and such measurable items as

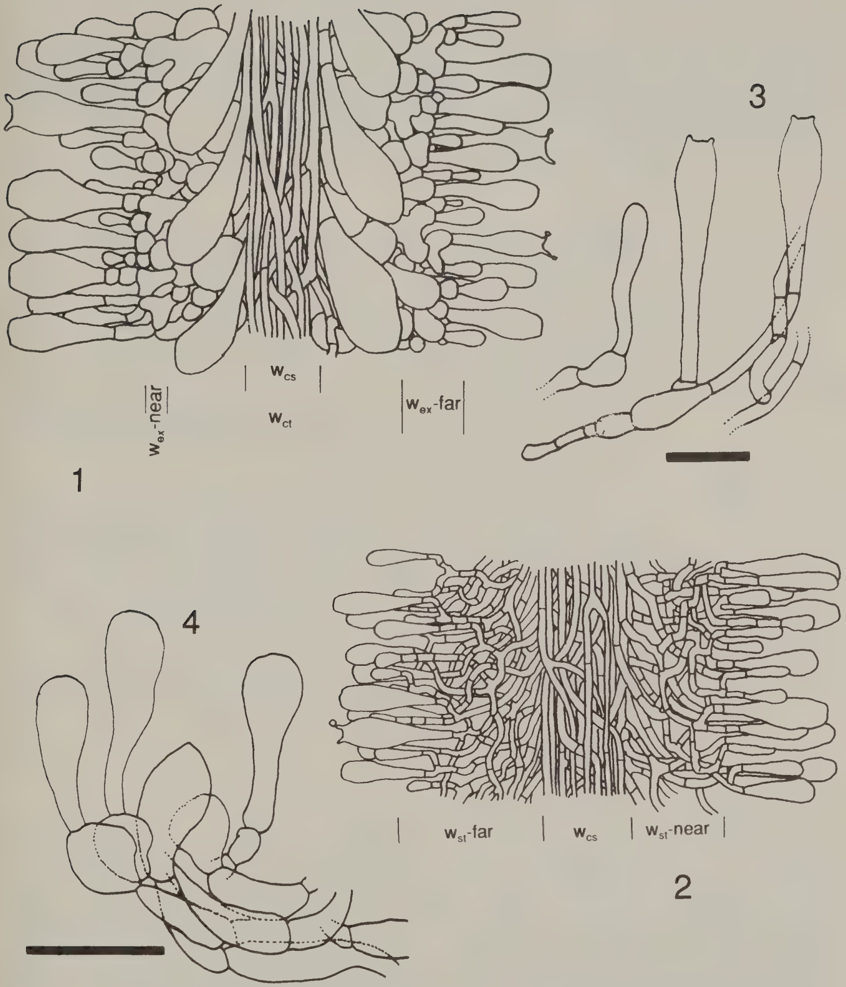
- the above defined angle between diverging elements and the central stratum

- the range of numbers of cells between the base of the hymenial elements and the c-trama or central stratum in cellular subhymenia

- presence or absence of terminal, inflated cells

- the presence or absence of elements that are roughly parallel to the central stratum, but located adjacent to the bases of basidia (whether such elements were branches of the subhymenium or hyphae of a particularly broad and dominating central stratum).

Because I felt that the use of a limited set of terms might be preventing me from seeing or describing the real forms of the subhymenium and their variations, I wrote rather lengthy descriptions of that tissue [*e.g.*, see Tulloss *et al.* (1992)]. In as yet unpublished work sent to me for comment, Dr. Bas introduced the idea of measuring the width of the central stratum and the subhymenium. I have adopted this idea and now always measure widths of the central stratum, the c-trama (when divergent, terminal, inflated cells are present), the portion of the subhymenial tree extending beyond the c-trama, etc. In measuring the subhymenial tree, there are at least four widths that may be important (according to the presence or absence of divergent, terminal, inflated cells). The number of measurements is increased because of the



**Figs. 1-4.** Fig. 1 A schematic rendering of the ''canonical'' *Amanita* lamella trama with prominent, diverging, terminal, inflated cells. Abbreviations introduced in this paper for widths of certain regions of the lamella trama are related to those widths. Fig. 2 Schematic presentation of elements of hymenium and complexly tangled subhymenium in a case in which divergent, terminal, inflated cells are absent from the lamella trama. Abbreviations introduced in this paper for widths of certain regions of the lamella trama are related to those widths. Fig. 3 *Amanita cylindrispora* Bearsdlee [xii.1935 H. C. Beardslee *s.n.* (CUP 25548)]. Elements of hymenium and subhymenium, illustrating lack of inflated cells in the subhymenium. Dark scale bars in anatomical drawings represent 20 µm. Fig. 4 *Amanita peckiana* C. H. Kauffm. *apud* Peck {Guravich *s.n.* [=Tulloss 9-21-86-A] (RET)}. Elements of hymenium, subhymenium, and central stratum——illustrating a much reduced subhymenial tree.

sometimes considerable differences in distance between bases of basidia/basidioles and the limit of the c-trama or central stratum [see discussion of the ''subhymenial tree'' by Bas (1969: 327 including Fig. 11)]. I make the set of these measurements at about the midpoint between the pileus context and the edge of a lamella; in this region, the faces of lamella are often roughly parallel. I begin reporting such data in the present paper. It is convenient to have abbreviations for the widths as follows:

$w_{cs}$ = width of the central stratum (Figs. 1 and 2)

$w_{ct}$ = width of the core trama (restricted in use to cases in which divergent, terminal, inflated cells are relatively common——Fig. 1)

$w_{st}$-near = depth of subhymenial tree measured from an outer edge of the central stratum to the nearest base of a basidium or basidiole (Fig. 2)

$w_{st}$-far = depth of subhymenial tree measured from an outer edge of the central stratum to the most distant base of a basidium or basidiole of the nearest hymenial surface (Fig. 2)

$w_{ex}$-near = width of the exposed subhymenium——measured from the outermost point on a divergent, terminal, inflated cell to the nearest base of a basidium or basidiole (restricted in use to cases in which divergent, terminal, inflated cells are relatively common——Fig. 1)

$w_{ex}$-far = width of the exposed subhymenium——measured from the outermost point on a divergent, terminal, inflated cell to the most distant base of a basidia or basidiole on the nearest hymenial surface (restricted in use to cases in which divergent, terminal, inflated cells are relatively common——Fig. 1).

It is important to note that these measurements are probably only accurate to within ±5 µm at best and vary between individual basidiocarps of a species. These measurements also require careful sectioning, staining with Congo Red or other cell wall stain (important anyway for the detection of clamps), and the discipline to review multiple sections from each specimen examined——so that errors due to incomplete rehydration of tissue or displacement of tissues by the sectioning process or partial crushing during mounting can be detected to the greatest degree that is achievable.

At present, my understanding of the degree of variation within a species is still developing; and, for example, I would not propose a taxonomic distinction based on a difference in breadth of the central stratum unless

- material from several collections were examined
- there was reason to believe that a good degree of rehydration was occurring consistently in tissues of both supposed taxa

- the proposed distinction was supported by other character differences.

On the other hand, I believe that differences between two entities with regard to the form and size of the subhymenium do justify separation of those entities at the rank of species. Indeed, I have not found such a difference that was not also accompanied by other character differences such as pileus color, ratio of length of marginal striation to pileus radius, structure of the universal veil, or statistically significant differences in spore measurements.

*Additional cautions and notes.* The identification of (terminal) inflated elements requires a caution stated succinctly by Reijnders (1993). ''The recognition of a widened element in a tissue is sometimes precarious in a two-dimensional section. Interhyphal spaces often suggest inflated elements. Another deception can be due to the fact that a widened element represents just a part of an otherwise much thinner hypha which has not been sectioned. Comparative observations and proof of the presence of a proper wall are essential.''

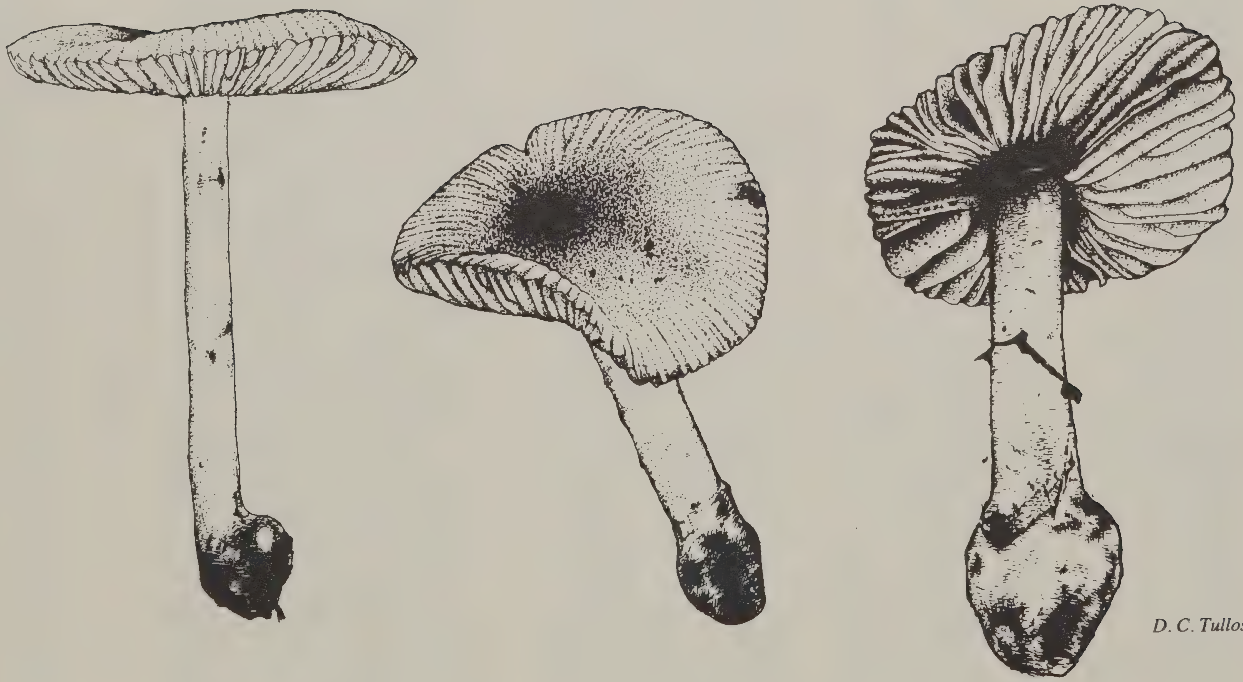
When divergent, terminal, inflated cells are missing or rare in the lamella trama, it may be difficult to distinguish the limits of the central stratum because branch elements of the subhymenium may run parallel to the central stratum and seem to be part of it——unless such elements are carefully traced to a connection with a subhymenial tree. Alternatively, hyphae of the central stratum may be displaced toward the bases of the basidia by sectioning or mounting. Finally, the subhymenial tree may include a combination of inflated cells and uninflated hyphae diverging at a very shallow angle. (I have found this confusing structure in *A. constricta* Thiers & Ammirati.) Some combination of these cases may occur. Appropriate caution must be exercised in describing such tissue.

Finally, I have not made use of the following character in this paper; but I have found in recent type studies in *Amanita* section *Vaginatae* and in related work on undescribed taxa of that section from the Pacific Northwest of the U.S.A. that there seems to be a species specific range of the number of cells that occur (in a chain) between the the base of the shortest basidiole in a small region of the hymenium (say, a region less than 200 μm long in a lamella section) and the longest basidium/-ole in that region. I was quite surprised to find that the ranges for this cell count might be nearly disjoint (one-half to two and one-half cells *vs.* two and one-half to five cells) in two taxa sufficiently similar to have been included among the paratypes of a single species (*A. constricta*). The form of these (usually) small cells in the interstices between the longer hymenial elements is also variable, possibly species specific, and worth recording in a description of a subhymenium.

## TAXONOMIC PART

### 1. *AMANITA PACHYSPERMA* Atk. 1918. *Proc. Amer. Philos. Soc.* 57: 354.

*Amanita pachysperma* (Fig. 5) is a very small mushroom with a pale gray pileus; an annulate, white stipe; and a saccate volva. It appears to be associated with *Quercus*.



D. C. Tulloss del.

Fig. 5 *Amanita pachysperma* (Tulloss 8-6-88-A) habit (x2.2). Dark object on rightmost stipe is detritus from substrate.

PILEUS: 15 - 27 mm wide, light gray to gray (5B2), sometimes with dark gray disk, convex and umbonate at first, then planoconvex, finally with central depression, dull, slightly sticky or dry; *context* white, unchanging when cut or bruised, 1 - 1.5 mm thick, thinning rapidly to a point about half-way to margin, then a membrane; *margin* sulcate to tuberculate-striate (0.35 - 0.45R), nonappendiculate, sometimes slightly decurved; *universal veil* absent or as an irregular patch, membranous, white, often with its surface impregnated with sand.

LAMELLAE: narrowly adnate or adnexed to barely free, subdistant to subcrowded to crowded, pure white both in mass and in side view, 2.5 - 3 mm broad, occasionally anastomosing; *lamellulae* truncate to subtruncate to subattenuate, of variable length, unevenly distributed.

STIPE: 23 - 50 x 3 - 6 mm, pure white, not changing when cut or bruised, narrowing upward, not flaring or only slightly flaring at apex, faintly longitudinally striate (lens), somewhat floccose or fibrillose (lens), with its surface occasionally breaking up into girdle-like formations, fragile; *base* rounded or obconic; *context* white, occasionally pale reddish brown in very base, unchanging when cut or bruised, solid to stuffed to hollow, in the latter cases with a central cylinder 1 - 1.5 mm wide; *partial veil* white, superior to median, membranous, fragile, small, often lost; *universal veil* as a small cup or saccate, slightly greater than 1 mm thick at midpoint between point of attachment and topmost point of limb, pure white, somewhat leathery, not fragile, 7 - 13 mm from stipe base to highest point of limb, 5 - 8 mm across.

*Odor* of *Russula adusta*[1] Fr. (Singer collection) or odorless (Tulloss 8-6-88-A & Tulloss 7-17-91-C). *Taste* not recorded. Edibility unknown.

MACROCHEMICAL TESTS: Phenol - maroon (Singer collection).

PILEIPELLIS: $20^{\pm}$ µm thick; filamentous, undifferentiated hyphae 1.5 - 5.5 µm wide, dominantly subradially arranged, tightly interwoven, partially to totally gelatinizing, with a slightly browner tint than adjacent pileus context; vascular hyphae not distinguishable. PILEUS CONTEXT: filamentous, undifferentiated hyphae 3.0 - 8.0 µm wide, occasionally up to 17.5 µm wide and then with walls thickened (0.5 - 0.8 µm thick); acrophysalides plentiful, thin-walled, ellipsoid to clavate to narrowly clavate, up to 68 x 39 µm; vascular hyphae 1.8 - 12.0 µm wide, common, branching. LAMELLA TRAMA: bilateral, with $w_{cs}$ = 30 - 40 µm, with central stratum sometimes partially obscured by inflated or partially inflated cells of the subhymenium; with divergent elements exiting central stratum at a shallow angle, sometimes at an angle of about 45° or more to central stratum when reaching bases of basidia; filamentous, undifferentiated hyphae 2.5 - 6.0 µm wide, some with rather frequent swollen intercalary segments; divergent, terminal, inflated cells not observed; vascular hyphae 1.5 - 3.8 µm wide, locally common, branching; clamps present. SUBHYMENIUM: $w_{st}$-near = 30 - 55

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[1] Described by Kibby and Fatto (1990) as "often of old wine casks."

µm; $w_{st}$-far = 55 - 60 µm; filamentous, undifferentiated hyphae frequently branching and short-segmented outside the central stratum; elongate, intercalary, subinflated to inflated hyphal segments frequent, sometimes in short chains, sometimes clavate, sometimes narrowly subfusiform to bacilliform, up to 75 x 21 µm, thin-walled, sometimes arising in central stratum and with major axis roughly parallel to same, curving away from the central stratum smoothly until reaching an angle of 30° - 45° to it and giving rise to short elements near the bases of basidia, with end nearest basidia sometimes recurved slightly; short hyphal segments (including a variable number inflated) dominant near basidia bases with many running at shallow angle to central stratum; in some regions, small inflated cells (up to 29 x 18.5 µm, but mostly smaller, e.g., 9.0 x 8.5 µm) locally dominant in three to six layers; with basidia arising from inflated cells or from the end or the side of an uninflated to partially inflated hyphal segment; clamps observed. BASIDIA: 24 - 56 (-67) x 8.0 - 14.5 (-15.5) µm, thin-walled, at times with base curved to one side, dominantly 2-sterigmate, occasionally 4- or 1-sterigmate, with sterigmata up to 13.8 x 3.8 µm; clamps and proliferated clamps prominent, frequent. UNIVERSAL VEIL: *On pileus*: absent in material studied. *At stipe base, exterior surface*: a very thin layer of tightly interwoven hyphae with a few ventricose gaps here and there; filamentous, undifferentiated hyphae 1.5 - 7.5 µm wide, sublongitudinally oriented, often collapsing and slightly gelatinized; vascular hyphae $4.8^{\pm}$ µm wide, scarce. *At stipe base, interior*: filamentous, undifferentiated hyphae, 2.2 - 7.2 µm wide, often in fascicles, plentiful; inflated cells dominating, terminal, single, subglobose to ovoid to elongate to ellipsoid to subpyriform up to 105 x 63 µm; vascular hyphae $4.0^{\pm}$ µm wide. *At stipe base, inner surface*: like the interior except elements collapsed and gelatinized. STIPE CONTEXT: longitudinally acrophysalidic; filamentous, undifferentiated hyphae 1.5 - 10.2 µm wide, dominating, branching; acrophysalides thin-walled, up to 191 x 47 µm; vascular hyphae common, 3.0 - 6.5 µm wide, branching; clamps common. PARTIAL VEIL:[2] extensively gelatinized; with surface having irregularly scattered pits (evidently due to loss of inflated cells) up to 56 x 36 µm; filamentous, undifferentiated hyphae with co-parallel orientation; internal inflated cells not observed; vascular hyphae not distinguishable due to gelatinization.

BASIDIOSPORES: [204/10/5] (9.5-) 10.5 - 16.2 (-20.0) x (6.0-) 7.5 - 10.5 (-12.5) µm, (**L** = (11.3-) 11.7 - 14.5 µm; **L'** = 13.1 µm; **W** = (8.1-) 8.6 - 9.7 µm; **W'** = 9.0 µm; Q = (1.12-) 1.26 - 1.75 (-2.10); **Q** = (1.30-) 1.31 - 1.64; **Q'** = 1.48), inamyloid, thin-walled, hyaline, smooth, ellipsoid to elongate, occasionally cylindric, sometimes subfusiform, usually at least somewhat adaxially flattened; apiculus sublateral, cylindric, often quite broad (e.g., 3.2 µm across); contents granular to guttulate; white in deposit.

*Habitat and distribution*: Occurring in July and August, western North Carolina to eastern Massachusetts and Rhode Island, solitary to subgregarious, in grass near mature *Quercus* (Singer collection) or in packed loamy soil near *Quercus sp.* and *Rhododendron maximum* L. (Tulloss 8-6-88-A) or in pine-oak barrens dominated by

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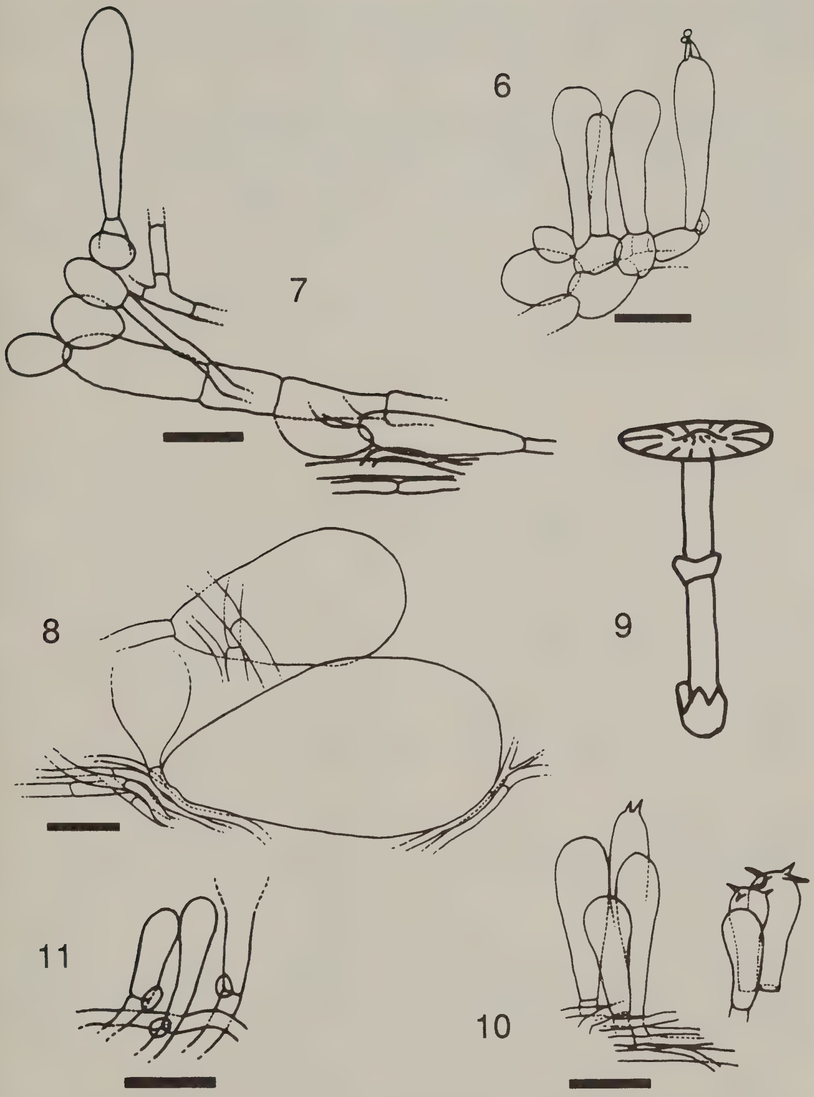
[2] No tissue assignable to the partial veil could be located on specimens of the holotype. In his type study, Jenkins (1982) found "exclusively filamentous hyphae 3 - 8 µm diam." The data presented here are from a flake on stipe of Tulloss 8-6-88-A.



**Figs. 6-11.** Figs. 6-8. *Amanita pachysperma*. 6. Elements of hymenium and subhymenium——inflated region and basidial clamp (Singer collection). 7. Elements of hymenium and subhymenium——relationship to central stratum (Tulloss 7-17-91-C). 8. Elements of interior of universal veil from stipe base (Singer collection). Figs. 9-10. *Amanita subvirginiana* (holotype). 9. habit (x1), after field sketch of W. A. Murrill. 10. Elements of hymenium and subhymenium——uninflated region. Fig. 11. *Amanita virginiana* (holotype) Elements of hymenium and subhymenium——frequently seen uninflated form of subhymenium and basidial clamps.

*Pinus rigida* Miller with several species of *Quercus* as scrub (Tulloss 7-17-91-C) or in mixed deciduous woods with *Quercus* present (Tulloss 7-25-92-D). The holotype was collected in mixed deciduous and coniferous forest.

*Collections examined*: **UNITED STATES:** CONNECTICUT—Litchfield Co. - Washington Twp., N of Washington Depot, Bee Brook Pk., 25.vii.1992 B. Eldering *s.n.* [Tulloss 7-25-92-D] (RET). MASSACHUSETTS—Suffolk Co. - Cambridge, Observatory Park, vii.1942 M. & R. Singer *s.n.* (FH; field notes in F). NEW JERSEY—Monmouth Co. - near Helmetta, Jamesburg Twp. Pk., R. E. Tulloss 7-17-91-C (RET). NORTH CAROLINA—Watauga Co. - Blowing Rock, 19.viii-19.ix.1899 G. F. Atkinson 3711 (holotype, CUP-A). RHODE ISLAND—Washington Co. - near Kingston, 6.5 km S of University of Rhode Island campus, 6.vii.1988 Rick Van de Poll *s.n.* [Tulloss 8-6-88-A] (RET).

## DISCUSSION

The investigations reported in this paper were undertaken as a result of my finding a packet containing material of the present taxon marked ''*A. biovigera* type'' in FH. Dr. C. Bas, L, advised me that the name first appeared in (Singer, 1951 [''1949'']: 387). The citation is in a list of taxa assigned to *Amanita* section *Ovigerae* Sing. and consists entirely of the following: ''*A. biovigera* Sing. [*A. strangulata* (Fr.) Quél. sensu Bres. non al.]''. Dr. Bas pointed out to me that, because Bresadola's description was in Latin, the brief quotation just cited results in a valid publication of *A. biovigera*. Dr. Bas was very generous in sending me notes that he had prepared on the subject several years ago. He had examined potential syntypes of *A. biovigera* among Bresadola's collections at S and found this material to have 4-sterigmate basidia. The composite from his spore measurements is as follows: [25/3/3] (10.8-) 11.2 - 13.9 (-14.4) x (8.2-) 8.3 - 11.5 (-11.7) µm, (**L** = 11.7 - 12.9; **L'** = 12.4 µm; **W** = 8.6 - 10.4 µm; **W'** = 9.8 µm; Q = (1.07-) 1.08 - 1.45 (-1.51); **Q** = 1.18 - 1.35; **Q'** = 1.27). (It should be noted that the specimen with **Q** of 1.18 was annotated ''juvenilis'' by Bresadola.) The description of Bresadola (1927: 18 & Tab. XVIII) includes an umbrinous (but not dark) pileus 80 - 100 mm wide and a stipe 120 - 160 x 11 - 15 mm. [The color of the pileus in the accompanying plate is between *Light Brownish Olive* and *Buffy Olive* or a little lighter (due to uneven application of pigment in the illustration).] It became clear that *A. biovigera* cannot be the correct name of its apparently once-intended type. During a visit to F, I was shown and given permission to copy Dr. Singer's original field notes, which give a good account of the fresh material of the Observatory Park collection.

Jenkins (1982) reported a study of the holotype collection of *A. pachysperma* that matches my observations on the Singer material in every detail except for the fact that basidial clamps had not been observed. Re-examination of the holotype revealed relatively common clamps and proliferating clamps. The holotype is in poor condition—reduced to fragments that are somewhat difficult to handle. For this reason, repetition of a complete anatomical study of the type was not attempted. Spore size and shape as well as the structure of the lamella trama and subhymenium were examined in the type and, along with macroscopic characters, were emphasized in determining the recent collections.

The shortest spores of any collection examined were those from Tulloss 8-6-88-A (**L** = 11.3 - 11.7 µm). Tulloss 8-6-88-A was collected during a dry, hot period in which the daytime temperature in Rhode Island regularly rose to over 38° C. The basidiocarps of *A. pachysperma* are quite small and, as such, particularly liable to the impact of environmental stresses. Therefore, it seems reasonable that such conditions might cause production of smaller spores than usual. In the same regard, Tulloss 7-25-92-D was collected in the wet and relatively cool July of 1992, the **Q** and **L** values calculated for this specimen (1.63 and 14.4 µm respectively) were the second highest recorded for both of the variables.

As has been noted by Jenkins (1986), the anatomies of *A. virginiana* and *A. pachysperma* are very similar. I decided against using figures showing the interior structure of the universal veils of all three taxa treated in this paper because they are essentially identical. *Amanita pachysperma* differs from the other two taxa treated herein in at least six characters:

- pigmentation of the pileipellis

- closeness of lamellae (those of *A. pachysperma* being most crowded)

- size and shape of spores

- completeness of the outer layer of the universal veil (that of *A. pachysperma* nearly completely covering the interior, while the interior is commonly exposed between parallel fascicles of hyphae in the other two taxa)

- quantity of vascular hyphae in the pileus context (common in *A. pachysperma*, scarce or absent in the other two taxa)

- amount of inflation in elements of the subhymenium (frequently, more elements inflated in *A. pachysperma*) and of the lamella trama (terminal, divergent, inflated cells absent in *A. pachysperma*).

It must be noted that in the sections of *A. virginiana* lamella trama in which the greatest degree of inflation was seen, the similarity to the lamella trama of *A. pachysperma* was striking; a shallower angle of divergence and occasional, divergent, terminal, inflated cells were the differences. Based on limited observations, it appears that the partial veil of *A. pachysperma* is lost more readily than the partial veils of the other two taxa. See also subsequent discussion sections.

In the past, I have refered to this taxon as "*Amanita sp. N21*" and "*Amanita sp. 47*" in checklists and correspondence.

### 2. *AMANITA SUBVIRGINIANA* (Murr.) Murr. 1941. *Mycology* 33(3): 287.

≡*Venenarius subvirginianus* Murr. 1941. *Mycology* 33(3): 286.

*Amanita subvirginiana* (Fig. 9) is a very small mushroom with a uniformly avellaneous pileus having a long striate, concolorous margin; its stipe is white and decorated with a small, submedian annulus and a saccate volva. The following macroscopic description is based on the protologue, Murrill's notes deposited with the holotype, and my observations of the holotype.

PILEUS: 20 mm wide, uniformly avellaneous, convex to plane, not umbonate, somewhat viscid; *context* white, very thin; *margin* concolorous, striate (0.5R), entire; *universal veil* absent.

LAMELLAE: adnexed, subdistant to subcrowded, white, dark brown in exsiccatum, entire, neither very broad nor very thin, not forked, slightly ventricose; *lamellulae* not described by Murrill.

STIPE: 40 x 3.5 - 4 mm, milk-white, narrowing upward, dry, smooth, minutely pubescent (lens); *context* color not recorded, hollow in exsiccatum; *partial veil* white, unchanging when cut or bruised, subsuperior to median, fixed, small, membranous, simple, persistent; *universal veil* as a saccate volva, white, narrow, lobed, with free limb.

*Odorless. Taste* not recorded. Edibility unknown.

MACROCHEMICAL TESTS: None recorded.

PILEIPELLIS: 40 - 45 µm thick; filamentous, undifferentiated hyphae 2.0 - 4.5 µm wide, densely interwoven, subradially arranged, slightly gelatinized; vascular hyphae not observed; clamps common. PILEUS CONTEXT: filamentous, undifferentiated hyphae 2.0 - 10.0 µm wide, plentiful, often in loosely interweaving fascicles; acrophysalides subfusiform to fusiform to clavate to broadly clavate to ellipsoid, up to 90 x 44 µm, dominant, thin-walled; vascular hyphae not observed. LAMELLA TRAMA: bilateral, angle of divergence dominantly very shallow to not diverging, but also (occasionally) up to nearly 45°, with $w_{ct}$ = 70 - 75 ($-90^{\pm}$) µm and $w_{cs}$ = 30 - 40 µm; filamentous, undifferentiated hyphae 1.0 - 8.0 µm wide, thin-walled, densely interwoven, branching; inflated cells sparse, obscured by hyphae, thin-walled, broadly clavate to clavate to narrowly clavate to subfusiform, up to 66 x 27 µm, aligned with hyphae of central stratum or diverging with hyphae that give rise to subhymenium, sometimes with apex reaching bases of basidia; vascular hyphae 2.2 - 11.0 µm wide, branching, sinuous. SUBHYMENIUM: $w_{ex}$-near = $0^{\pm}$ µm; $w_{ex}$-far = $5^{\pm}$ µm; $w_{st}$-near = $35^{\pm}$ µm; $w_{st}$-far = $55^{\pm}$ µm; largely composed of branching hyphae at a very shallow angle to the central stratum, with small cells up to three to four deep below the basidia in some regions (up to 16.0 x 11.0 µm, most three-quarters of this size or less), with filamentous, undifferentiated hyphae running subparallel to the central stratum interwoven at basidia bases; basidia mostly arising from uninflated (sometimes quite long) hyphal segments, but occasionally arise from the side of small ellipsoid cells (up to 13.5 x 8.2 µm) that are terminal on such hyphae. BASIDIA: 30 - $50^{\pm}$ x 9.0 - 12.2 µm (but few in condition to be measured in holotype), thin-walled, fragile, probably dominantly 4-sterigmate, but also often (about one-third or more) 2-, and occasionally 1-sterigmate; sterigmata up to 9.5 x 3.5 µm; clamps and proliferated clamps large and common (difficult to see in holotype because of poor condition of tissue). UNIVERSAL VEIL: *On pileus*: absent. *At stipe base, exterior surface*: comprising widely spaced, longitudinally oriented, rather extensively gelatinized, rather thick fascicles of hyphae between which can be seen the inflated cells, etc. of the interior; filamentous, undifferentiated hyphae 1.5 - 8.0 µm wide; vascular hyphae not distinguishable due to gelatinization. *At stipe base, interior*: filamentous, undifferentiated hyphae 1.5 - 15.0 µm wide, branching, plentiful, loosely interwoven around inflated cells singly or in fascicles, occasionally having refractive material deposited unevenly (up to slightly more than 1.0 µm thick) on interior walls, with some of larger diameter having slightly thickened walls (less than 0.5 µm thick); inflated cells terminal, single, dominating, subglobose to broadly ellipsoid (up to 65 x 57 µm), subfusiform to clavate to narrowly clavate (up to 135 x 42 µm), thin-walled or with walls slightly thickened (up to 0.5 µm thick); vascular hyphae $2.8^{\pm}$ µm wide, very scarce; clamps plentiful. *At stipe base, inner surface*: gelatinized, otherwise like the interior. STIPE CONTEXT: longitudinally acrophysalidic; filamentous, undifferentiated hyphae 2.5 - 9.5 µm wide, branching, plentiful, dominating near surfaces; acrophysalides thin-walled, plentiful, dominating away from surfaces, up to 156 x 37 µm, base often broadly rounded, basal septum sometimes eccentric; vascular hyphae 2.8 - 15.0 µm wide, relatively common away from surfaces. PARTIAL VEIL: almost completely gelatinized in holotype; with surface having irregularly scattered pits (evidently due to loss of inflated cells) up to 69 x 48 µm; filamentous, undifferentiated hyphae 1.5 - 4.5 µm wide, with some subradially oriented and others co-parallel and perpendicular to those of the first group; inflated cells not observed within the tissue; vascular hyphae not observed.

BASIDIOSPORES: [40/1/1] (9.0-) 10.2 - 14.0 (-15.5) x (6.2-) 7.8 - 10.2 (-11.8) µm, (**L** = 11.7 µm; **W** = 8.7 µm; Q = (1.22-) 1.25 - 1.47 (-1.54); **Q** = 1.35), hyaline, smooth, thin-walled or occasionally with walls slightly thickened (0.5 µm or less thick) and then somewhat opaque, inamyloid, broadly ellipsoid to ellipsoid, adaxially flattened; apiculus sublateral, rather small, cylindric; contents granular to multiguttulate (although in the holotype most spores have no visible contents); color in deposit unknown.

*Habitat and distribution*: Solitary, in low humus of hammock (a term peculiar to Florida and indicating usually mesic, climax vegetation——hardwood forest including *Quercus*, *Magnolia*, etc.——often slightly elevated compared to surrounding terrain).

*Collection examined*: **UNITED STATES:** FLORIDA——Alachua Co. - *ca.* 5 km SE of current (1992) city line of Gainesville, Prairie Creek Hammock, 27.iii.1938 W. A. Murrill F16134 (holotype, FLAS).

## DISCUSSION

The single specimen of the holotype is in only moderately good condition and very fragile. The stipe is broken just below the annulus, and about a quarter of the pileus remains tenuously connected to the top of the stipe. The tissues of the hymenium, subhymenium, and lamella trama are fragile, possibly partially deteriorated, and not very strongly congophilous; this situation makes examination rather difficult. For example, despite the fact that clamps are large and plentiful at the base of the basidia, they are so faint (even at 1000x) that one must search for them diligently. No other specimen of this species was located.

The current taxon is very similar anatomically to *A. virginiana* and, consequently, differs from *A. pachysperma* (see discussion under *A. pachysperma*). *Amanita subvirginiana* differs from *A. virginiana* in pileus color, thickness of the pileipellis, frequency of 4-sterigmate basidia, the size and frequency of vascular hyphae in the lamella trama, the occurrence of spores with slightly thickened walls, and possibly (*N.B.*: the sample is very small) in spore size. Considering the condition of the holotype of *A. subvirginiana*, it seems prudent to wait until fresh material can be collected before drawing a final conclusion about its taxonomic relationship to *A. virginiana*.

Singer (1950) equated "*A. spreta* var. *minor* Beardslee" [*A. spreta* var. *parva* Beardslee (1908) was intended] with *A. subvirginiana*. The Beardslee taxon has an extremely limited protologue and is of dubious taxonomic value at present. For more details concerning *A. spreta* var. *parva*, see the discussion under *A. virginiana*, below.

Murrill interprets something in the hymenium of the present species as large, clavate cystidia of which he says, "inflated, obtuse, thin-walled, hyaline, scanty, projecting about 20 µ". I saw nothing that could be interpreted as a cystidium. An occasional basidium will project up to 10 µm or so beyond the rest of the hymenium; this is quite common in *Amanita*.

W. A. Murrill F17496 (FLAS), collected in pine woods in Gainesville, is labeled *A. subvirginiana* and was determined by Murrill. According to one of the notes in the packet, Murrill found the spores to be 10 - 12 x 6 - 9 µm. According to R. Singer's notes (F), he examined this specimen and confirmed the determination. There is presently no pileus in the packet. The stipe and volva in the packet are of the same size and form as those of the holotype specimen. Murrill's notes in the packet read as follows:

> Amanita - Pine wds 7-7-38 solitary/ Sl viscid 2 cm, nearly white + sl smoky disk, marg striate/ gs + ridge to st. ring median[.] volva limb [drawing of small subtriangular limb] to [illegible][.] bulb small/ Small form of A. gemmata/ Cf. subvirginiana
>
> [spore drawing with one guttule] 10-11 x 6-7/ sm/ subovoid 1-gut
>
> subovoid/ = 10-12 x 8-9
>
> cf. subvirginiana but color dif + spores too narrow - Habitat very dif

New collections of similar material (very pallid pileus and otherwise like *A. subvirginiana*) would be very useful in understanding the present species; and new material is badly needed to supplement the holotype collection.

Two other collections in FLAS labeled *A. subvirginiana* proved not to belong to section *Vaginatae*. Apparently the present species is quite rare.

My findings are an extension of those of Jenkins (1979). The present taxon is omitted by Jenkins (1986) in his survey of *Amanita* in North America.

3. *AMANITA VIRGINIANA* (Murr.) Murr. 26 Sep 1914. *Mycologia* 6: 269.

≡*Venenarius virginianus* Murr. 28 Jul 1914. *N. Am. Flora* 10(1): 71.

*Amanita virginiana* (Fig. 12) is a small to very small mushroom with brownish gray to dark brown to gray-brown to fuliginous disk and pallid pileus margin. Its white stipe is decorated by a superior to median to subinferior, white partial veil that is usually persistent. The universal veil is found as a sheathing volva or as warts on the pileus and, in the latter case, a set of small splayed limbs on the stipe base suggesting a kernel of popped corn. The species appears to be associated with *Quercus* and *Fagus*.

PILEUS: 7 - 50 mm wide, fuliginous to dark brown to gray-brown to brownish gray (*e.g.* 10YR 6/2) or umbrinous gray over disk, the gray tones becoming apparent upon expansion, at times with brown tints becoming stronger after collection, pallid to white to sordid cream to tan toward margin, hemispheric at first, then convex to plane, often depressed over disk in all stages of expansion, glabrous, moist to slightly sticky to viscid, becoming shiny when dry; *context* white, infrequently with unevenly distributed pale gray regions, sordid or brownish under pileipellis, infrequently brownish in disk near apex of stipe, unchanging when cut or bruised, 0.5 - 2.5 mm thick at stipe, thinning evenly for about one-half to two-thirds of radius, then a membrane to margin; *margin* striate to tuberculate-striate, with long striations [(0.35-) 0.45 - 0.55R], nonappendiculate, decurved at first, flaring upward in maturity; *universal veil* absent or as pallid, detersile warts or small patches.

LAMELLAE: free to narrowly adnate to adnate, with or without decurrent line on stipe, subdistant to close, white to off-white in mass and in side view, becoming sordid in age, unchanging when cut or bruised, 1 - 5 mm broad, margins fimbriate; *lamellulae* truncate to rounded truncate to subtruncate, of diverse lengths, originating both at margin and stipe.

STIPE: 8 - 70 x 2 - 7 mm, white, faintly browning from handling, cylindric or (infrequently) narrowing downward, slightly expanded at base where confluent with universal veil, sometimes slightly flaring at apex, finely pulverulent near apex, smooth to satiny below, becoming finely fibrillose below (lens), longitudinally striatulate (lens); *context* white to off-white, unchanging when cut or bruised, hollow or firmly stuffed with white material in 0.5 - 4 mm wide central cylinder, concolorous in larva

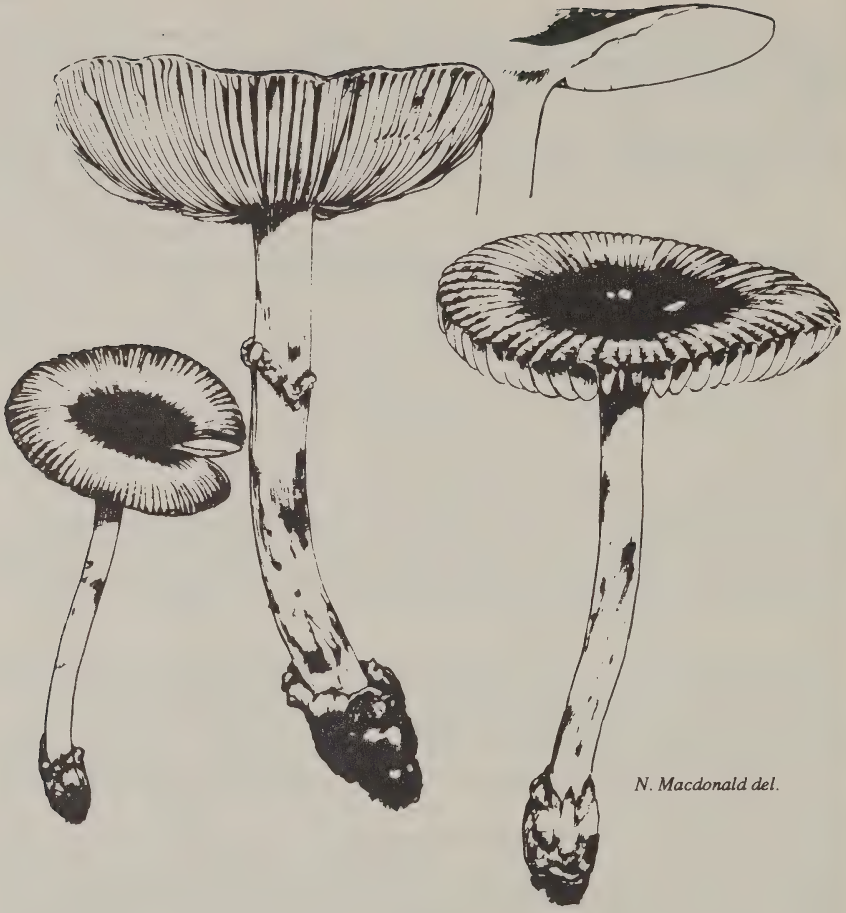

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Fig. 12 *Amanita virginiana* (Tulloss 7-1-84-E) habit (x2.0).

tunnels; *partial veil* subapical to superior to median to subinferior, white, usually persistent, thin, small, at first membranous and skirt-like, collapsing with age, occsasionally only present as a fibrous-fibrillose line, not apparent on some exsiccata (including the holotype); *universal veil* as a conspicuous cup or small sac, sheathing or with flaring limbs suggesting a kernel of popped corn, leathery and tough, white, adnate to stipe base, up to 13 mm from stipe base to highest point of volval limb.

*Odor* absent or ''mild'' (Began 388). *Taste* not distinctive. Edibility unknown.

MACROCHEMICAL SPOT TESTS: Spot test for tyrosinase (paracresol) - slowly positive (after 5 min. or more) in universal veil, stipitipellis, pileipellis, and top and bottom of stipe; accompanied by faint positive reactions in lamellae and elsewhere. Spot test for laccase (syringaldazine) - negative throughout basidiocarp.

PILEIPELLIS: $20^{\pm}$ µm thick, orange-brown in 3% KOH; filamentous, undifferentiated hyphae 1.8 - 8.5 µm wide, tightly interwoven, predominantly subradially arranged, extensively gelatinizing; vascular hyphae not observed. PILEUS CONTEXT: filamentous, undifferentiated hyphae 1.2 - 7.2 µm wide, plentiful, branching, often in fascicles; acrophysalides dominating, thin-walled, clavate to broadly clavate to ellipsoid, up to 84 x 52 µm; vascular hyphae 4.8 - 5.0 µm wide, rather scarce. LAMELLA TRAMA: bilateral, difficult to rehydrate in holotype, with $w_{ct}$ = 95 - 105 µm in recently collected and well-dried material, with $w_{cs}$ = 30 - 55 µm; divergent elements leaving central stratum at shallow angle, divergent hyphae (almost immediately beginning to branch to form the subhymenium) more easily/frequently seen than divergent, terminal, inflated cells; filamentous, undifferentiated hyphae 1.0 - 3.4 µm wide, with some intercalary segments inflated up to 14.5 µm wide; divergent, terminal, inflated cells up to 43 x 23 µm, ellipsoid to clavate, thin-walled; vascular hyphae 2.1 - 3.2 µm wide, uncommon to very scarce. SUBHYMENIUM: $w_{ex}$-near = $0^{\pm}$ µm; $w_{ex}$-far = 10 - 20 µm; often composed entirely of filamentous, undifferentiated hyphae 3.0 - 6.0 µm wide, having short segments, interwoven, some subparallel to the hymenial surface, with occasional segments slightly inflated to narrowly ellipsoid; inflated cells (fully inflated segments of aforementioned hyphae) present occasionally, in some regions dominating, up to 10.2 x 7.5 µm, but most smaller, up to four layers deep; basidia arising from ends and sides of uninflated and inflated hyphal segments. BASIDIA: 33 - 53 x 9.8 - 14.0 (-14.5) µm, thin-walled, the great majority 2-sterigmate, occasionally 1-sterigmate; clamps common, prominent. UNIVERSAL VEIL: *On stipe base, external surface*: filamentous, undifferentiated hyphae 2.0 - 6.0 µm wide, branching, in fascicles that are sufficiently widely spaced so that the interior structure is visible between them, sublongitudinally oriented, partially gelatinized; clamps present. *On stipe base, interior*: filamentous, undifferentiated hyphae 2.0 - 7.2 µm wide, collected in fascicles surrounding inflated cells, with walls slightly thickened in those of largest diameter; inflated cells subpyriform to broadly clavate to clavate to narrowly clavate or elongate, dominant, up to 132 x 42 µm, with cell walls thin or slightly thickened (up to $0.5^{\pm}$ µm thick), giving impression of longitudinal orientation to the tissue (however, many cells are not longitudinally aligned); vascular hyphae $2.5^{\pm}$ µm wide, scarce; clamps present. *On stipe base, inner surface*: like the interior except somewhat collapsed and gelatinized. *On pileus*: not present in holotype; in other collections, similar to material at stipe base. STIPE CONTEXT: longitudinally acrophysalidic; filamentous, undifferentiated hyphae 1.8 - 8.0 µm wide, branching, dominant; acrophysalides thin-walled or with slightly thickened walls (up to 0.5 µm thick), plentiful, up to 195 x 55 µm; vascular hyphae 3.5 - 18.0 (-19.0) µm wide, branching, locally rather common; clamps common. PARTIAL VEIL: not located in holotype[3]; upper surface pocked [probably by loss due to gelatinization of ovoid to ellipsoid to clavate cells (*e.g.*, 75 x 45 µm) that permit separation of lamellae from partial veil]; filamentous, undifferentiated hyphae 2.0 - 11.2 µm wide, partially gelatinized, interwoven, frequently branching, subradially arranged at surface, criss-crossed below surface, often in fascicles, rather easily dissociated (at least when not part of a fascicle); inflated cells (other than surface cells) ellipsoid to ovoid to clavate (up to 75 x 45 µm) and narrowly clavate to elongate (up to 305 x 35 µm, but mostly less than 200 x 35 µm), in chains or singly, terminal, thin-walled, partially gelatinizing, very fragile and difficult to detect in exsiccata; vascular hyphae up to 2.5 - 6.3 µm wide, branching, locally common and in tangles and knots; clamps plentiful.

BASIDIOSPORES: [900/45/16] (9.1-) 11.5 - 15.0 (-20.5) x (6.5-) 8.5 - 11.2 (-15.5) µm, (**L** = (11.7-) 12.3 - 14.0 (-14.1) µm; **L'** = 13.2 µm; **W** = (9.1-) 9.4 - 10.6 (-10.9) µm; **W'** = 9.9 µm; Q = (1.07-) 1.16 - 1.51 (-1.89); **Q** = (1.16-) 1.23 - 1.41 (-1.55); **Q'** = 1.33), hyaline, thin-walled, smooth, amyloid, broadly ellipsoid to ellipsoid, often somewhat adaxially flattened, often expanded at one end; apiculus subapical to sublateral, small to moderately broad, cylindric; contents dominantly monoguttulate, also multiguttulate to granular; white in deposit.

*Habitat and distribution*: Western Virginia to eastern Massachusetts and westward to Illinois; scattered to subgregarious to gregarious; late June to late August. Holotype gregarious in moist, gravelly bank, *Quercus* woods, 1465 m elev. Washington Crossing collections gregarious in well-groomed lawn under and around an old, solitary specimen of *Q. rubra* L. with *Cornus florida* L. and *Aesculus hippocastanum* L. nearby. Massachusetts collection in sandy soil under *Quercus*, *Acer*, *Pinus*, and *Tsuga*. Illinois collection scattered on canyon floor in sandy soil under *Fagus grandifolia* Ehrh.

*Collections examined*: **UNITED STATES:** ILLINOIS——Jackson Co. - Shawnee Nat. For., Little Grand Canyon, *ca.* 8 km S of Murphysboro, 20.viii.1986 Timothy J. Began 388 (SIU). MASSACHUSETTS——Middlesex Co. - Lincoln, $1^{\pm}$ km W of Walden Pond, Old Concord Rd., Adams Woods, 1.viii.1982 Roy E. Halling 3489 (NY). NEW JERSEY——Mercer Co. - Washington Crossing St. Pk., arboretum area, Mary A. King & David C., Mark H., & R. E. Tulloss 7-1-84-E (F; L; NY; RET), R. E. Tulloss 7-5-84-A through -F (RET), D. C. & R. E. Tulloss 6-23-85-C (RET), M. A. King & D. C., Sarah E. K. & R. E. Tulloss 7-5-92-B (RET). Morris Co. - Bernardsville, 23.vii.1984 R. Miller & Dorothy Smullen *s.n.* [Tulloss 7-23-84-RMDS4] (RET); Mendham, Meadow Woods Twp. Pk., New Jersey Mycological Assoc. member *s.n.* [Tulloss 7-22-84-H] (RET). NEW YORK——Dutchess Co. - Pine Plains, Mt. Stissing/Thompson Pond Preserve, 2.viii.1990 William Bakaitis 90-67 (RET). Rockland

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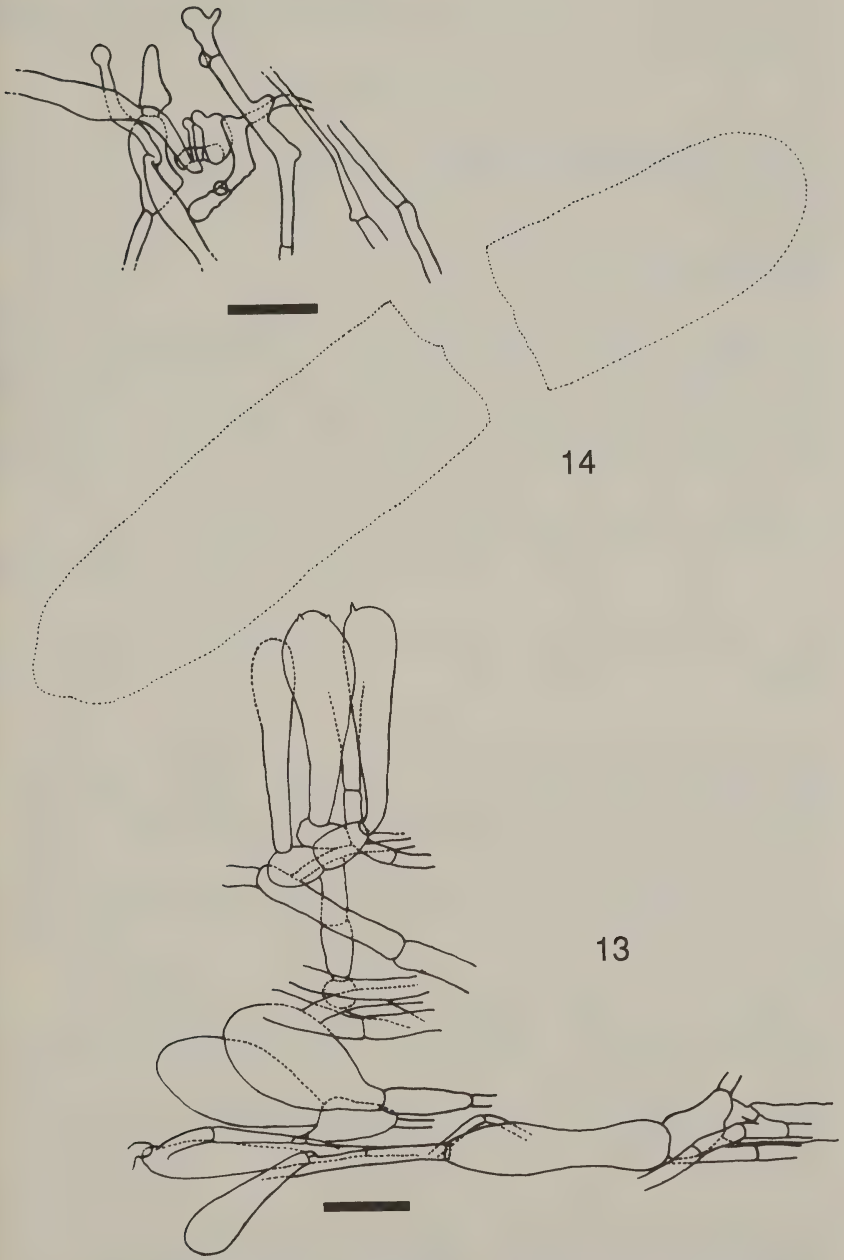
[3] This description is based on partial veils in Halling 3489 and Tulloss 7-5-84-C.



Figs. 13-14. *Amanita virginiana*. 13. Elements of hymenium and subhymenium—relationship to central stratum (elements of subhymenial region partially separated by mounting) (Tulloss 7-5-92-B). 14. Elements of partial veil (Halling 3489).

Co. - Harriman St. Pk., Lake Sebago, 23.vii.1963 Bill Isaacs 2154 (MICH). VIRGINIA——Giles Co. - near Mountain Lake, 8-14.vii.1909 W. A. Murrill 28 (holotype, NY; isotype, NCU).

## DISCUSSION

Inflation of the short hyphal segments of the subhymenium was not seen in all specimens and was usually seen only locally in those specimens in which it occurred. I have the impression that inflation of such cells is more common in *A. pachysperma*. For further comparison of *A. virginiana* to the other taxa treated in this paper, see the previous discussion sections.

Coker (1917) equated *A. spreta* var. *parva* with *A. virginiana* [for which he reports the spore measurements of 11 - 13 x 7.5 - 10.5 µm (est. **Q** = 1.36)]. Coker determined as *A. spreta* var. *parva* his collection Coker 1624 (NCU? (*n.v.*)) for which he gives the spore dimensions as 10 - 12.6 x 6.7 - 8.2 µm (est. **Q** = 1.53). These spores are considerably narrower than those of *A. virginiana*. The spores of *A. spreta* var. *parva* as described by Beardslee are very nearly the size given by Coker [10 - 12 x 7 - 8 µm (est. **Q** = 1.47)]——smaller than those measured for any of the taxa treated in this paper. As a consequence, it seems unwise to accept Coker's proposal of synonymy of *A. spreta* var. *parva* with *A. virginiana* without further evidence. Coker 1624 could not be located in NCU. A packet in NCU marked "Amanita spreta var. parva ex type" proved to contain a small box marked in black ink "*Venenarius virginianus* Part of type" in what appears to be W. A. Murrill's hand; the material inside was indeed *A. virginiana*.

Coker's description of *A. spreta* var. *parva* reads "This is an extremely little form of *A. spreta* and is a small plant with a very pale cap, and veil not smoky. Cap 3.5 cm. broad, pale buff in center, fading to nearly white on margin which is strongly striate. Gills attached, about 3 mm. deep, white. Stem 13 cm. long, 6 mm. thick, finely fibrillose below the veil, minutely granular above; a distinct central cylinder that is lightly stuffed. Veil a small collapsed ring 2 cm. from the cap, white. Volva long, narrow, attached to the very base of the stem, which is not bulbous. Spores elliptic, 6.7-8.2 x 10-12.6 µ." Note that the stipe length does not match that of any taxon treated herein, and the cap color is more like that of *A. subvirginiana* than that of *A. virginiana*.

I could find no evidence that a type of *A. spreta* var. *parva* exists or has ever existed; and I could find no authentic material of the taxon. There is no authentic material of *A. spreta* var. *parva* in MICH (in which Beardslee's herbarium is now included). In Beardslee's files (preserved at MICH), there is no file for *A. spreta* var. *parva*; nor is mention of this taxon made in Beardslee's file on *A. spreta* (Peck) Sacc. (examined by me). Moreover, it seems very unlikely that, if a type of *A. spreta* var. *parva* were known to Coker, he would have designated what he considered to be the type of a synonym (*A. virginiana*) as the type of *A. spreta* var. *parva* in his herbarium. Since the Beardslee taxon is poorly described and apparently lacks a type, it must be considered to be of questionable taxonomic value at present. If it can be defined clearly in the future and, moreover, is proven to be a variety of *A. spreta*, its basidia would be expected to be dominantly 4-sterigmate.

In NY, I found a packet (W. A. Murrill 179) with label indicating that it was a topotype of *V. virginianus* collected during the same period as was the holotype. Murrill must never have checked the spores of this collection, which is clearly not conspecific with the holotype. As noted by L. R. Hesler (annotation slip attached to packet of Murrill 179), the spores of the single specimen in the packet are globose to subglobose.

The Washington Crossing St. Pk. (New Jersey) collections were made in a lawn that was frequently mowed. The specimens were short enough to survive the mowings intact. Since seven collections were made at this site in a period of five days (1-5 July 1984) and since it is possible that they represent fruiting of a single mycelium, it is of interest to see the amount of variation in spore size and shape measured on the specimens of these collections: [380/19/7] (9.1-) 11.5 - 14.5 (-16.2) x (6.5-) 8.8 - 11.5 (-13.0) µm, (**L** = (12.3-) 12.5 - 13.6 (-13.7) µm; **L'** = 13.0 µm; **W** = (9.5-) 9.6 - 10.7 (-10.9) µm; **W'** = 10.1 µm; Q = (1.07-) 1.12 - 1.48 (-1.76); **Q** = (1.16-) 1.19 - 1.38 (-1.39); **Q'** = 1.30).

An isolate from Began 388 provided the basis for cultural studies reported in (Began, 1988).

## KEY TO NORTH AMERICAN TAXA OF SECTION VAGINATAE WITH SMALL BASIDIOCARPS AND FREQUENTLY TO PREDOMINANTLY BISTERIGMATE BASIDIA

1. Basidiocarp entirely white except for frequently pinkish white or orangish white lamellae; marginal striation on pileus relatively short; spores (9.2-) 10.2 - 13.9 (-17.0) x (6.6-) 7.0 - 9.0 (-12.8) µm, with **Q** = 1.42 - 1.57............ *Amanita ristichii.*

1. Basidiocarp with pigmented pileipellis, white lamellae, and long marginal striations on pileus.

    2. Pileus gray, occasionally darker over disk, lacking any brown tones, not avellaneous; lamella trama lacking terminal, inflated cells, but with rather plentiful, partially inflated intercalary elements; spores (9.5-) 10.5 - 16.2 (-20.0) x (6.0-) 7.5 - 10.5 (-12.5) µm, with **Q** = (1.30-) 1.31 - 1.64........... *Amanita pachysperma.*

    2. Pileus brown over disk and paler at margin or uniformly avellaneous; lamella trama dominated by hyphae of diameter ≤ 8.0 µm with scattered, terminal, inflated cells.

        3. Pileus some shade of brown over disk, paler towards margin; basidia dominantly bisterigmate; spores (9.1-) 11.5 - 15.0 (-20.5) x (6.5-) 8.5 - 11.2 (-15.5) µm, with **Q** = (1.16-) 1.23 - 1.41 (-1.55)............................ *Amanita virginiana.*

3. Pileus uniformly avellaneous; one-half to two-thirds of basidia 4-sterigmate; spores (9.0-) 10.2 - 14.0 (-15.5) x (6.2-) 7.8 - 10.2 (-11.8) µm, with **Q** = 1.35 ........................................................................ *Amanita subvirginiana.*

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# NOTES ON HYPHOMYCETES. LXIII.
# NOVEL SPECIES OF FULIGOMYCES AND TRETOSPORA FROM INDIA, WITH COMMENTS ON THE GENERA

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## ABSTRACT

*Fuligomyces indica* Khan & Kamal and *Tretospora shoreae* Khan & Kamal, two new species of Hyphomycetes occurring on living leaves of *Shorea robusta* Gaertn., are described and illustrated from collections made in the forests of Uttar Pradesh and Bihar, India, respectively. They are compared with other members of these genera, and a key to species of *Tretospora* is provided.

## INTRODUCTION

Ongoing investigation and field collection of foliicolous forest Hyphomycetes in northeastern Uttar Pradesh and Bihar have, in recent years, led to the discovery of a significant number of previously undescribed anamorph fungal taxa (Narayan and Kamal, 1986; Verma and Kamal, 1987, Verma *et al.*, 1989; Kamal *et al.*, 1990a, 1990b, 1991; Chaudhary *et al.*, 1991). It is anticipated that the mycofloras of these regions and habitats include many other hitherto unknown species. Continued surveys can be expected to yield many more novel taxa. Herein, two additional new species, one each of *Fuligomyces* Morgan-Jones & Kamal and *Tretospora* Hansford, are described and illustrated. Both occur on living leaves of *Shorea robusta*.

The genus *Fuligomyces* was established for a sooty mold, in the broad vernacular sense, occurring superficially on the abaxial surface of leaves of *Casearia elliptica* Willd. in India (Morgan-Jones and Kamal, 1984). It is characterized by production of long, somewhat undulate, obclavate, dematiaceous dictyoconidia, produced holoblastically from repent hyphae. The conidia of the type species, *F. macrosporus* Morgan-Jones & Kamal, have something of a cheiroid aspect toward their apex in that they branch, with each extension having a finger-like appearance. Individual branches are short, determinate, more or less parallel-sided and usually closely appressed, composed of a single, linear series of short cells. In general morphology, the conidia of *F. macrosporus* bear slight resemblance, although different in overall shape, to those of some species of *Monodictys* Hughes, such as *M. antiqua* (Corda) Hughes and *M. lepraria* (Berk.) M.B. Ellis, and their holoblastic ontogeny from micronematous conidiophores is similar. Its conidia do not, however, possess the basal, paler, thinner-walled cell characteristic of *Monodictys* and the habit of the two genera is, in any case, entirely different. With respect to branching, though much less extensive and divergent, there is some similarity between *F. macrosporus* dictyoconidia and phragmoconidia of the monotypic *Taeniolina* M.B. Ellis, based on *T. centaurii* (Fuckel) M.B. Ellis. That fungus infects leaves of *Centaurium erythraea* Rafn, with conidiophores emerging through stomata. A superficial resemblance also exists between conidia of *F. macrosporus* and those of *Ceratosporella stipitata* (Goidanich) Hughes. In the latter, conidia are usually composed of three or four tightly appressed branches, all originating from a single basal cell (Hughes, 1952), and are produced solitarily on macronematous, dark-brown conidiophores. Among sooty molds, the monotypic genus *Capnocheirides* Crane & Hughes, established for *C. rhododendri* (Kunze in Corda:Fr.) Crane & Hughes (Crane and Hughes, 1982), has somewhat similar habit and morphology to *F. macrosporus*. Originally classified in the genus *Torula* Pers.:Fr., it occurs superficially on living leaves of *Rhododendron* spp. in Europe and is rather unique. Its conidial initials, that arise holoblastically from ill-defined, macronematous conidiophores or directly from hyphal cells, vaguely resemble immature *Fuligomyces* conidia. These have, as the generic name indicates, a hand-like or cheiroid aspect with a number of finger-like, appressed or divergent branches, each subdivided into a series of short cells. These cells disarticulate schizogenously and basipetally to give rise to arthroconidia somewhat in the manner of *Wallemia sebi* (Fr.) Arx (Hashmi and Morgan-Jones, 1973).

The generic name *Tretospora* M. B. Ellis was proposed (Ellis, 1976) to accommodate anamorphs of two species of *Balladynopsis* Theiss. & Syd. [Ascomycetes, Dothideales, Parodiopsidaceae]. The type species, *T. negrii*, is the conidial state of *B. negrii* (Castellani) M. B. Ellis, whereas the other original taxon is referred to as the *Tretospora* state of *Balladynopsis vanderystii* Hansf. (Hansford, 1957). They are characterized by being hyphopodiate and producing obclavate, brown, thick-walled, rostrate, septate conidia from monotretic conidiogenous cells. *Clasterosporium* Schw., in contrast, which is also hyphopodiate and has similar conidia, produces them monoblastically, each delimited by a wide, distinct transverse septum (Ellis, 1958), which splits schizogenously along its length at secession, giving a truncate base. It is the hyphopodiate counterpart of *Sporidesmium* Link:Fr., with teleomorphs, where known, in the genera *Asterina* Lév. and *Asterodothis* Theiss. [Ascomycetes, Hemisphaeriales, Asterinaceae]. This is another example of a monothetic difference in otherwise superficially similar fungi reflecting phylogenetic distance. Luttrell (1979) referred to conidia of *Tretospora* as aleuriospores, bearing a basal hilum originating as a thick septum pierced by a pore. Schoknecht and Crane (1984), however, in describing *Torula quaternata* Berk. & Curt., which they reclassified as *Tretospora*

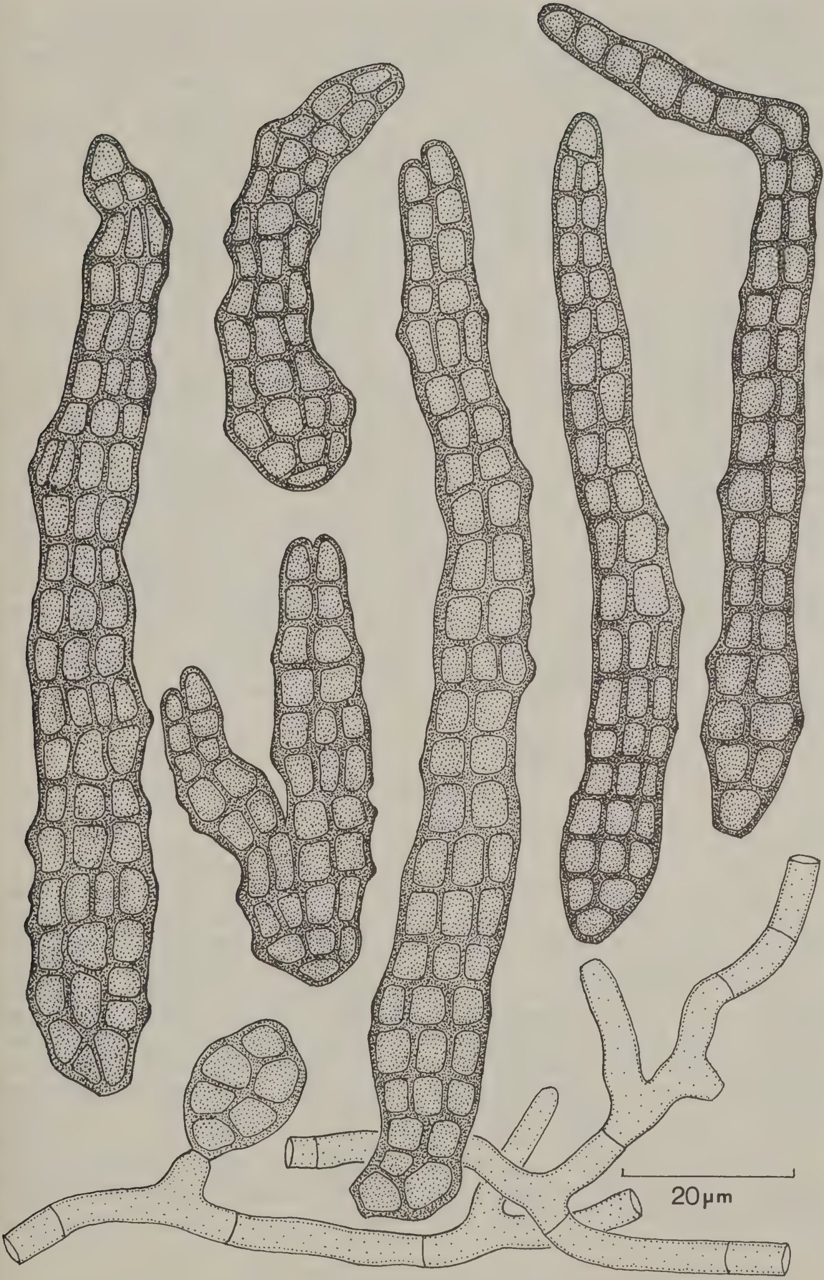

FIGURE 1. *Fuligomyces indica*. Mycelium, conidiophores and conidia.

*quaternata* (Berk. & Curt.) Schoknecht & Crane, confirmed the tretic nature of *Tretospora* conidiogenous cells. In *T. quaternata*, the conidiogenous cell wall was reported to be composed of a multilayered outer entity and a separate inner layer. No continuity could be found between the outer wall layers of the conidiogenous cell and those of a developing conidium. This species differs from the two original taxa in possessing much shorter, less septate conidia that, though obclavate in shape, are not rostrate and in having rough-walled hyphopodia. Narayan and Kamal (1986) named and described a fourth species of *Tretospora*, *T. indica* Narayan & Kamal. This is of broadly similar morphology to *T. negrii* and the anamorph of *B. vanderystii* but has conidia that are much wider in their broadest part, giving a doliiform shape.

*Tretospora quaternata* bears similarity to the genus *Pirozynskia* Subramanian, whose type species, *P. farriae* Subramanian, is the anamorph of *Maurodothina farriae* Pirozynski & Shoemaker [Ascomycetes, Hemisphaeriales, Asterinaceae]. Both the type species of *Maurodothina* Arnaud ex Pirozynski & Shoemaker, *M. dothideoides* (Ell. & Everh.) Pirozynski & Shoemaker, and *M. farriae* have a *Pirozynskia* anamorph, although neither this generic name nor any other have, to our knowledge, been applied to the conidial state of the former. *Maurodothina* differs from *Viegasia* Bat. only by the presence of the anamorph (Luttrell, 1973). *Pirozynskia farriae* produces short, more or less obclavate, one-septate, verrucose conidia from tretic conidiogenous cells that morphologically closely resemble hyphopodia and are considered modified forms of those structures (Ellis, 1976). Pirozynski and Shoemaker (1970) referred to them as conidiogenous hyphopodia. The conidia differ from those of *Tretospora* in not having a very dark, truncate, basal hilum and in being septate rather than pseudoseptate. *Tretospora quaternata* conidia are, likewise, different from those of the other four species in these respects.

## TAXONOMIC PART

### *Fuligomyces indica* Khan and Kamal sp.nov. (Figure 1)

Coloniae semper epiphylleae, extense effusae, discretae vel confluentes, griseo-atrae. Mycelium superficiale, ex hyphis pallide brunneis, laevis, ramosis, septatis, repentibus, 2.5-3.5 µm crassis compositum. Conidiophora micronemata, monomenata. Cellulae conidiogeneae monoblasticae, in hyphis vegetativis incorporatae, terminales vel intercalares, cylindricae. Conidia solitaria, sicca, ex apice lateribusque hypharum oriunda, cylindrica vel leniter obclavata, plus minusve variabilia in formae, recta vel flexuosa, versus apicem et basim irregulariter ramosa, apicem versus leviter descrescentia et pallide brunnea, laevia vel irregulariter aspera, muriformia, ad basim truncata, usque ad 270 µm longa, 7-15 µm crassa, ad apicem obtusa vel rotundata.

In foliis vivis *Shoreae robustae*, Raniapurwa, Sohelwa West Forest, Bahraich, Uttar Pradesh, India, February 1991, M.K. Khan, HCIO 30792 holotypus, GPU Herb. No. KS 275 isotypus.

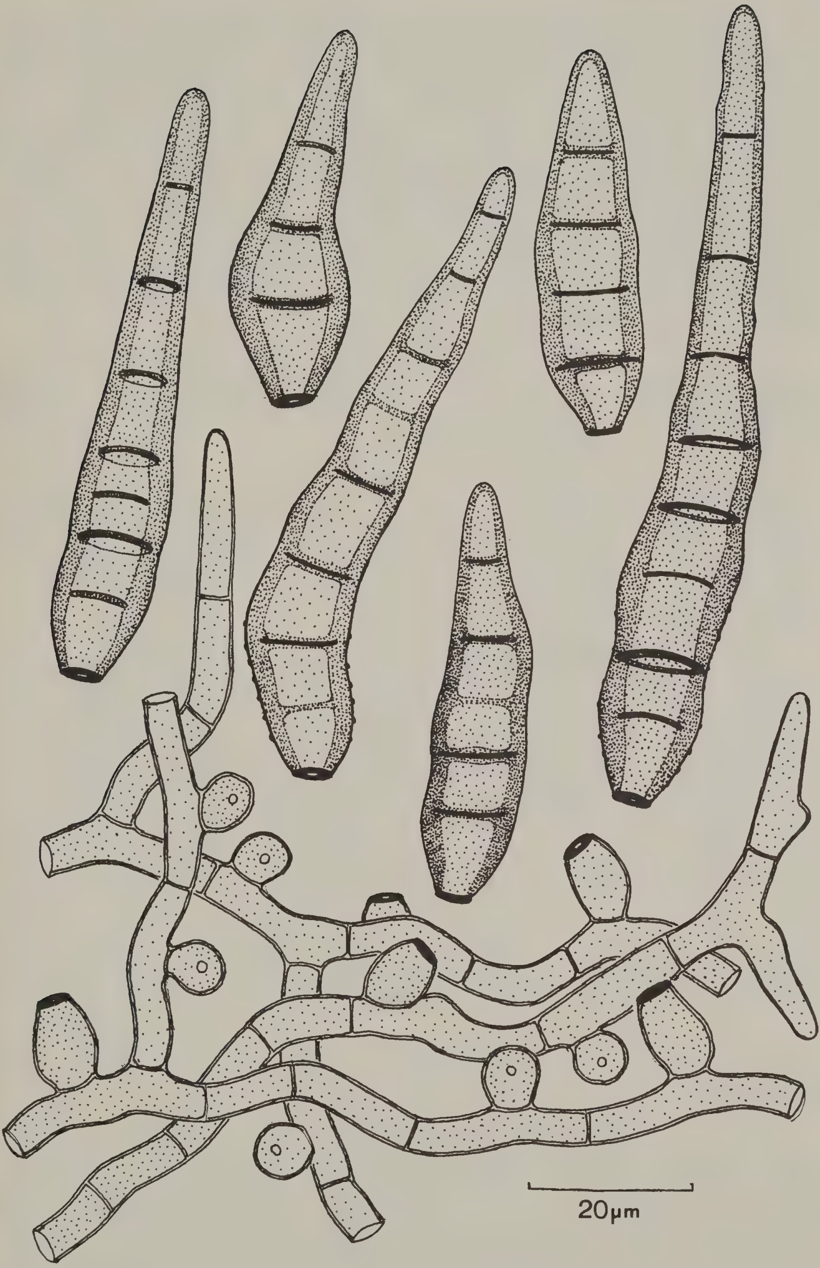

FIGURE 2. *Tretospora shoreae.* Mycelium, hyphopodia, conidiophores and conidia.

Colonies always epiphyllous, usually spreading extensively, often over the entire leaf surface, discrete or confluent, sooty black. Mycelium superficial, composed of pale brown, smooth, branched, septate, repent, 2.5-3.5 µm wide hyphae. Hyphae interwoven, forming an abundant loose network on the leaf surface. Conidiophores micronematous, mononematous. Conidiogenous cells monoblastic, incorporated in the vegetative hyphae, terminal or intercalary, cylindrical. Conidia solitary, dry, arising terminally or laterally from fertile, intercalary hyphal cells, cylindrical to slightly obclavate, somewhat variable in shape, straight or flexuous, sometimes irregularly branched near the apex or toward the base, apices tapering gradually and pale brown, smooth or irregularly roughened, muriform, with two or three vertical columns of small cells, frequently inflated in the lower region, base truncate, 50-270 X 7-15 µm, obtuse to rounded at the apex.

On living leaves of *Shorea robusta* Gaertn. (Dipterocarpaceae); India. Collection examined: on *S. robusta*, Raniapurwa, Sohelwa West Forest, Bahraich, Uttar Pradesh, India, February 1991, M.K. Khan, HCIO 30792, holotype, GPU Herb. No. KS 275 isotype.

*Fuligomyces indica* differs from *F. macrosporus*, the type species, in the size and morphology of its conidia. Those of the former are appreciably longer, are made up of far more cells, have a tendency to branch toward the base, and bear more prominent, scattered excrescences on their outer surface.

*Tretospora shoreae* Khan & Kamal (Figure 2)

Coloniae amphigenae, plerumque ad superior supraficiem, effusae, fuliginosae. Mycelium superficiale, ex hyphis ramosis et anastomosantibus, septatis, olivaceis, repentibus, reticulatis, laevis, usque 2 µm crassis compositum. Hyphopodia subglobosa vel reniformia, rare clavata, alternata, leniter opposita, fusca-olivacea, 6-8 µm lata. Conidiophora macronemata, mononemata ex hyphis superficialibus lateraliter et singulariter oriunda, parva, erecta, non-ramosa, aseptata, rare 1-septata, laevia, fusca-olivacea ad apicem fusca-brunnea, 10-14 X 7-7.5 µm. Cellulae conidiogenae integratae, enteroblasticae, monotreticae, terminales, cicatricibus, cicca atra coloratae usque 5 µm latae. Conidia solitaria, sicca singula in apice conidiophori per porum oriunda, recta vel leniter curvata, obclavata vel fusiformia, pallide brunnea vel atra brunnea, leniter verruculosa ad basim portionis, 3-8 pseudoseptata, laevia, ad supra portionis, 42-70 X 12-13 µm, apicem obtusa vel subacuta, usque 4 um lata, ad basim conicotruncata, 4.5-6 µm lata, hilo atro.

In foliis vivis *Shoreae robustae*, Topchachi, Dhanbad, Bihar, India, January 1992, M.K. Khan, HCIO 30875 holotypus, GPU Herb. No. KS 289 isotypus.

Colonies amphigenous, mostly on the upper surface, effuse, sometimes coalescing to form large colonies, sooty, black. Mycelium composed of superficial, hyphopodiate hyphae. Hyphae interwoven, branched and anastomosing, septate, repent, smooth-walled, up to 2 µm wide. Hyphopodia subglobose to reniform, rarely clavate, alternate to more or less opposite, dark olivaceous, 6-8 µm wide. Conidiophores macronematous, mononematous, arising

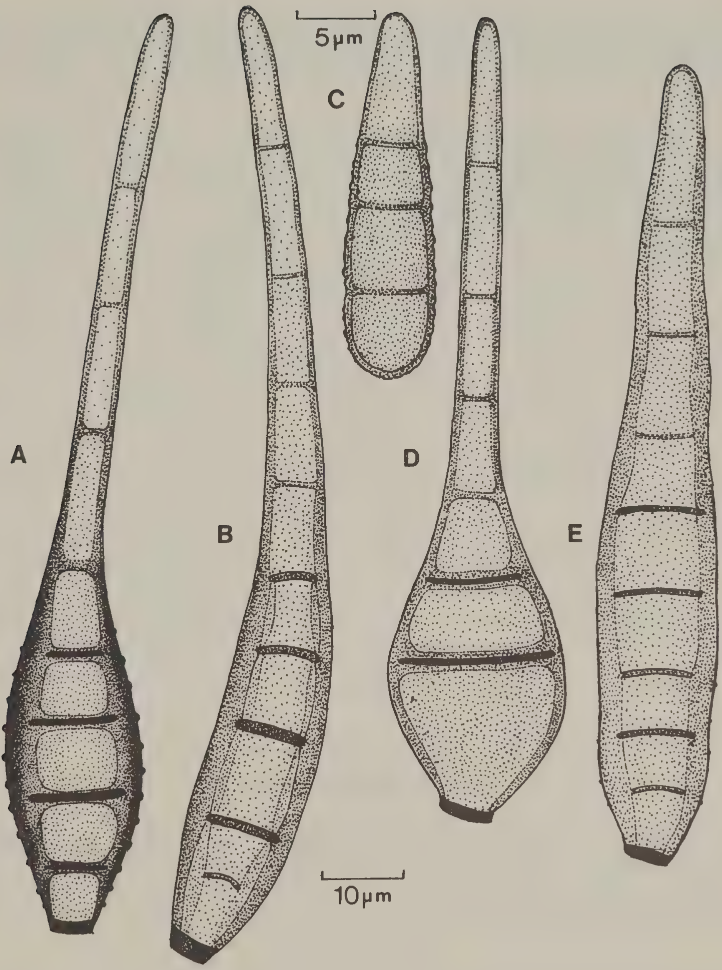

FIGURE 3. *Tretospora* conidia. A, *negrii*; B, anamorph of *B. vanderystii*; C, *quaternata*; D, *indica*; E, *shoreae*.

laterally and singly, short, unbranched, aseptate or rarely 1-septate, smooth-walled, olivaceous, 10-14 X 7-7.5 µm. Conidiogenous cells intergrated, enteroblastic, monotretic, terminal, cicatrized, with a dark brown apical rim, up to 5 µm wide. Conidia solitary, dry, arising singly, straight or slightly curved, obclavate to somewhat fusiform, pale to dark brown, slightly verruculose at the base, upper portion smooth, 3-8 transversely pseudoseptate, 47-70 X 12-13 µm, obtuse to subacute and up to 4 µm wide at the apex, base conicotruncate, 4.5-6 µm wide, bearing a dark hilum.

On living leaves of *Shorea robusta* Gaertn. (Dipterocarpaceae); India. Collection examined: on *S. robusta*, Topchachi, Dhanbad, Bihar, India, January 1992, M.K. Khan, HCIO 30875 holotype, GPU Herb. No. KS 289 isotype.

*Tretospora shoreae* differs from *T. negrii*, the *Tretospora* state of *B. vanderystii*, and *T. indica*, in lacking a distinct, long, narrow conidial beak (Figure 3). In that regard, it resembles *T. quaternata* although the conidia of that species are much shorter and are verruculose over their whole surface (Schoknecht and Crane, 1984). Conidia of *T. negrii* are also verruculose, whereas those of the remaining two species are smooth.

## KEY TO SPECIES OF TRETOSPORA

| | |
|---|---|
| Conidia distinctly rostrate with long, narrow beaks | 1 |
| Conidia obclavate, without pronounced beaks | 3 |
| 1. Conidia verruculose | *negrii* |
| 1. Conidia smooth | 2 |
| 2. Conidia narrowly obclavate | anamorph of *Balladynopsis vanderystii* |
| 2. Conidia doliiform | *indica* |
| 3. Conidia short (11-20 µm), up to 4-septate | *quaternata* |
| 3. Conidia long (42-70 µm), up to 8-septate | *shoreae* |

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# BOOK REVIEWS

L. M. Kohn, Book Review Editor

**Coelomycetous Anamorphs with Appendage-Bearing Conidia**, by T. R. Nag Raj. Hard cover, 285 x 220 mm, 1,101 pp., 1993. Mycologue Publications, 331 Daleview Place, Waterloo, Ontario, Canada N2L 5M5. ISBN 0-9692237-2-2. U.S. $129.-- (postage included).

This extraordinary publication exceeds all expectations for the major work of a taxonomic authority already renowned for his thoroughness, commitment to accuracy, and skillful illustration. The taxonomic part treats 142 genera (10 new), and 423 species (40 new). A further seven genera unavailable for study are included in an appendix with an evaluation of the original published descriptions. Thus all known genera of appendaged Coelomycetes are treated in a comprehensive manner. The genus and species descriptions are thorough and based on the author's original observations of fungi on the natural host or substrate. Cultural attributes, for the most part, were not studied. Type specimens were examined for almost all species treated. For rare species the type was frequently the only specimen examined. However, an impressive number of species treatments are based on multiple collections, evidence that the author has painstakingly searched the major herbaria for relevant material to develop species concepts. All of the treated species are illustrated by line drawings of exceptional accuracy and detail. Most illustrations are full page, and include a habit sketch of the conidioma, a vertical section through the conidioma showing cellular detail, and high magnification drawings of conidiogenous cells, conidial morphogenesis, and mature conidia. The line drawings are supplemented by eight photographic plates, documenting the more obscure features of conidium and appendage morphogenesis.

This publication's value as an identification and research resource is maximized by the author's conscientious effort to make the monograph comprehensive and complete. It was not feasible to study all of the species in many of the larger genera. However, the author lists and annotates all species not examined by him, with basic information including the original citation, synonyms, collection data, and location of the type specimen where known. For example the author provides detailed descriptions for 25 species of *Pestalotiopsis*; an additional 110 names of unexamined and excluded taxa are annotated as described above.

Useful synoptic and dichotomous-trichotomous keys to the genera are provided. In these the author appears to have taken care to avoid ambiguous characters. Characters chosen for the "dichotomous" key are mostly features of conidial morphology and appendage morphogenesis that can be reliably discerned with careful observation. Keys to species are also provided for genera with more than one treated species. However, for genera having some species not studied by the author, the reader should be aware that unexamined species are not included in the species keys.

In addition to the main taxonomic section, topics relevant to identification and research on appendaged Coelomycetes are discussed in separate chapters. These include a discussion of techniques for collecting, preparing and examining Coelomycetes, a review of diagnostic characters and of morphological and developmental terminology, and a treatment of conidium appendage morphogenesis in which eleven appendage types are distinguished. A glossary of terms and characters used in the description and keys is provided. The book concludes with comprehensive fungus, substrate and host indices that are inclusive of fungus names and hosts of species not examined by the author. The high quality of the paper, print and binding is commensurate with a volume that will stand as an irreplaceable reference for many years. The price of this publication is reasonable considering this quality. Dr. Nag Raj's book earns my enthusiastic recommendation, and is most certainly an essential resource for anyone with a serious interest in conidial or pathogenic fungi. *John Bissett, Centre for Land And Biological Resources Research, Agriculture Canada, Ottawa, Ontario, Canada*

**Nordic Macromycetes, Volume 2, Polyporales, Boletales, Agaricales, Russulales.** L. Hansen and H. Knudsen (Eds.). Soft cover, 154 x 249 mm, 474 pp., 1992. Nordsvamp, Gothersgade 130, DK-1123, Copenhagen K, Denmark (fax 45 35 32 23 21). ISBN 87-983961-0-2. DKK 375.-- (approx. U.S. $60.--).

It is invaluable to have complete coverage and diagnostic keys to the Nordic tundra, taiga, and boreal higher fungi. This enables mycologists in other parts of the world to compare species concepts with taxa which are present in the five nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) along with the northern islands including the Faroe Islands, Greenland, Svalbard, Jan Mayen, and Bjornoya. Another strong attribute of this work is the 31 authors who have contributed in their individual areas of expertise. This brings to the work a strong contemporary input. The areas of coverage and vegetation zones are both mapped and described. Instructions on how to use the text (flora) are illustrated (p.14-18) and every effort has been made to be totally consistent in the description and treatment of each taxon.

References to more detailed treatments of each genus follow the generic description. Following each species description in the diagnostic key are three references to color illustrations. However, no macroscopic illustrations of the species are presented in the text. Illustrations compliment the glossary which gives a brief but adequate explanation of the technical terms. In addition, over 1000 figures illustrate various microscopic features. These include drawings which illustrate the spore ornamentation of every taxon in the Russulaceae and the spore shapes in the Entolomataceae. Many important features of other higher taxa are also illustrated. An index to the generic names in Danish, Finnish, Icelandic, Norwegian, and Swedish is also provided.

There are generic keys within each family; genera, with keys to the species, are then presented in alphabetical order which greatly simplifies finding a genus without constantly consulting the index. The diagnostic keys are full paragraphs on each species with the vital information to differentiate closely related taxa. Another feature which I really like in a diagnostic key is the notation of the most consistently utilized synonyms. For example, an unusual *Omphalina* which I collected in alpine tundra near Abisko, Sweden, *O. viridimammata* Pilat, was the name given in my source at the time. This synonym listed along with *O. smaragdina* (Berk.) Malenc. & Berth. which is now the accepted binomial.

The work is published in what appears to be a durable paper back binding and its 15 x 25 cm size is convenient to carry. The book stays open when laid on a flat surface, the paper is glossy and of good quality. This is a quality work for a very reasonable price. I cannot imagine being interested in the higher Basidiomycetes and not having this informative work on my shelf. *O. K. Miller, Department of Biology, Virginia Polytechnic and State University, Blacksburg, Virginia, U.S.A. 24061.*

**Systematics of Laccaria (Agaricales) in the Continental United States and Canada, with Discussions on Extralimital Taxa and Descriptions of Extant types** (Fieldiana: Botany, New Series, No. 30, Publication 1435), by G. M. Mueller. Soft cover, 253 x 175 mm, 158 pp., 1992. Field Museum of Natural History, Library - Publications Division, Roosevelt Road at Lake Shore Drive, Chicago, Illinois 60605-2498, U.S.A. ISSN 0015-0746. US $36.-- includes shipping and handling for single copies of domestic orders; for two or more copies shipped to a U.S. address and for all foreign orders, add $1.50 per book.

This modern monograph is the culmination of the author's 12 years of work at five research institutions enhanced by some stimulating collaborations. The breadth of perspective in the consideration of biogeographical, ecological, genetic, morphological, cytological and molecular systematic relationships, and the cladistic analyses of morphological characters set this work apart. Based on extensive collections from the primary study area, the continental U.S. and southern Canada, with comparative material from Costa Rica, South America, and Sweden, nineteen species are recognized and *Laccaria laccata* is divided into two varieties. The Introduction provides a historical review and a discussion of all types of characters considered, followed by the cladistic analyses, Proposed Operational Classification of *Laccaria*, Conspectus of North American Taxa, Key to *Laccaria* Occurring in North America North of Mexico, full taxonomic descriptions of sections and species, Tentative Key to *Laccaria* for the World and descriptions of type collections (holotypes or lecto-/neotypes selected by the author) for all epithets that have been treated in the genus, Literature Cited, Appendix with Specimens Examined, Subject Index and, last, Index to Taxa. Descriptions of North American taxa are illustrated with black and white photographs, often helpful habit photos, as well as line drawings of basidia and basidiospores; comparative SEM micrographs of basidiospores are also provided. Anyone interested in this important genus and in North American agarics will want this book. We await the development of a DNA sequence data base for this group, within the context of the Basidiomycetes as a whole, that may clarify phylogenetic relationships and, more fundamentally, outgroups for this and other genera in the Agaricales. We also eagerly await the world monograph of *Laccaria*, a logical outgrowth of this ambitious project. *L.M.K.*

**European Polypores, Part 1** (Synopsis Fungorum, vol 6), by L. Ryvarden and R. L. Gilbertson. Hard cover, 160 x 230 mm, 387 pp., 1993. Fungiflora A/S, P.O. Box 95 Blindern, N-0314 Oslo 3, Norway. ISBN 82-90724-12-8, ISSN 0-802-8966. NOK 320.-- + postage.

This, the first of two volumes, treats the genera *Abortiporus* through *Lindtneria.* The format follows that of **North American Polypores** by Gilbertson and Ryvarden (1986-1987). Although **European Polypores** is an identification manual, four new combinations are proposed; no new species are described. The first 65 pages is a well-written introduction aimed at the beginning student. The principal points discussed are macro- and micromorphology, taxonomy, wood decay, pathology, culturing, mating systems, mycogeography, and collecting and identification. Next there is a key to the eleven families and 73 genera, which is detailed and often expects the user to have considerable knowledge of the generic concepts. The main part of the book, 306 pages, is devoted to descriptions and illustrations of the 165 species. The microscopic features of each species are pictured in line drawings.

The treatment of each species follows a standard format: Latin name, selected synonymy, macro- and microfeatures, type of rot, reference to descriptions of the cultural characters and mating system, substrata, distribution and remarks.

In a work this size it is inevitable that minor problems occur. For example, the keys to *Antrodiella* species are confused in places. In the first dichotomy, "Basidiocarps resupinate" should lead to choice 9, not 8; and in the synoptic key under "Habitat" (sic) species number 10 should be added to the group "always resupinate." The basidiospores illustrated for *Lindtneria trachyspora* are so different in shape and ornamentation from those in **North American Polypores** that the two hardly seem conspecific. Figures 141 and 142 should be reversed.

This is and indispensable reference for anyone interested in the polypores, regardless of the continent they live on. It provides a much needed broad overview of the European species and, I hope, will be the basis for much discussion of generic circumscriptions, taxonomically significant characters and the phylogenetic relationships between genera. Many of the old species names originated from European collections and they have been applied throughout the World. Thus the detailed descriptions in this volume should assure that the species names are accurately applied on other continents. Comparisons with the authors' North American manual are inevitable (77% of the species in volume 1 also occur in North America) and should result in a better understanding of the polypores of the North Temperate Zone. *J. Ginns, National Mycological Herbarium of Canada, Wm Saunders Bldg., Agriculture Canada, Ottawa, Ontario K1A 0C6.*

**Polyporaceae s.l. in Italia**, by Annarosa Bernicchia. Soft cover, 240 x 170 mm, 584 pp. + index and errata (as unbound booklet), 1990.Instituto di Patologia Vegetale, Università di Bologna, Via Filippo Re. 8, 40126 Bologna, Italia. £ 120.-- (Italian lire + postage).

This flora, written in Italian, treats 200 species in 74 genera of the Polyporaceae s.l. in Italy. Three new species are described: Antrodia macrospora Bernicchia and De Dominicis, Phellinus juniperinus Bernicchia and Curreli, and P. rosmarini Bernicchia. One new combination is proposed, Oligoporus simani (Pil.) Bernicchia. A brief introduction is followed by a list of the Polyporaceae s.l. found in central Europe. A key is provided for 74 genera within this list. Keys to the species appear under the treatment of each genus. The nomenclature follows that of Donk (1968) and Gilbertson and Ryvarden (1986, 1987).

The 74 genera are listed in alphabetical order. For each genus, an Italian description and the original description is provided, followed by a key to the species. Species within each genus are also described in alphabetical order. The species descriptions are comprehensive and follow a consistent format. Each species treatment includes a detailed description of the macro- and microscopic characters and data on distribution, habitat, and type of wood rot produced. Accompanying each description, on the adjacent page, is a color picture of the fruit body, a black and white picture of the pore surface and a line drawing of the microscopic features. One minor drawback for the novice using this book to identify collections is that for some species, a color picture of the fruit body is absent. Even a hand illustration of these species, like the one provided for Polyporus corylinus, would have been a very useful visual tool.

This is a well-organized, well-written and beautifully illustrated flora of the Polyporaceae s.l. in Italy. In addition to its usefulness in identification of specimens, this volume introduces the reader to the many different chemical compounds that are produced by polypores. By providing a brief description of these metabolites and their toxicological and therapeutic effects, it acts as a springboard for stimulating further interest in this group of fungi. The beginner will find this volume especially attractive because it includes a beautifully illustrated chapter describing the macro and microscopic features of polypores, the chemical reagents and techniques used in the preparation of microscopic mounts, and the various types of wood rot produced by polypores. A comprehensive bibliography and a glossary of scientific terms used in the text are also provided, making this volume readily accessible to the novice. This will be a very important reference in the identification of members of the Polyporaceae s.l. from Italy and central Europe. *I. Carbone, Dept. of Botany, Univ. of Toronto, Erindale College, Mississauga, Ontario, Canada.*

**The Lichen Flora of Great Britain and Ireland**, edited by O.W. Purvis, B. J. Coppins, D. L. Hawksworth, P. W. James, & D. M. Moore. Hard cover, 250 x 175 mm, 710 pp., 1992. Museum Publications, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (fax 071-938-9212) ISBN 0-565-01163-4. £50.--.

This comprehensive account of over 1700 taxa in 262 genera, compiled by 49 contributing lichenologists, is the first such treatment of British and Irish lichens since A. L. Smith's **Monograph of British Lichens** (1918-1926). Nomenclature follows Cannon et al.'s **The British Ascomycotina: an annotated checklist** (1985). It should be pointed out that the contributors include many of the world's lichen systematists and that the perspective in truly international despite the floristic focus. Techniques for collection, as well as morphological and chemical description of lichens are described in the Introduction as are principals of ecology and biogeography employed in the text. Diagnostic keys and descriptions of genera and species are provided, including invaluable information on worldwide, as well as British and Irish distributions. Illustrations are found only in the glossary, but are used in a comparative sense that should be quite helpful. Authors of the generic accounts are clearly indicated toward the end of the volume. A bibliography and a species index are also provided. This book, published in association with The British Lichen Society, will be used by a wide range of specialists, naturalists, and students of natural history. It is an excellent entry-level manual to the lichens. Clearly it will be invaluable to ecologists and those conducting environmental surveys. I look forward to using it to identify Canadian collections. *L.M.K.*

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# NOTICE

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Until such this as the directory is posted in the Harvard University Biodiversity and Biological Collections Gopher (Directories of Biologists) it is available via E–mail on request to Pavel Lizoň.

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